Appendix 1. WIND ANALYSIS

1. OBJECTIVE. This appendix provides guidance on the assembly and analysis of wind data to determine runway orientation. It also provides guidance on analyzing the operational impact of winds on existing runways.

a. A factor influencing runway orientation and number of runways is wind. Ideally a runway should be aligned with the prevailing wind. Wind conditions affect all airplanes in varying degrees. Generally, the smaller the airplane, the more it is affected by wind, particularly crosswind components (see figure A1-1). Crosswinds are often a contributing factor in small airplane accidents.

b. Airport planners and designers should make an accurate analysis of wind to determine the orientation and number of runways. In some cases, construction of two runways may be necessary to give the desired wind coverage (95 percent coverage). The proper application of the results of this analysis will add substantially to the safety and usefulness of the airport.

2. CROSSWINDS. The crosswind component of wind direction and velocity is the resultant vector which acts at a right angle to the runway. It is equal to the wind velocity multiplied by the trigonometric sine of the angle between the wind direction and the runway direction. Normally, these wind vector triangles are solved graphically. An example is shown in figure A1-1. From this diagram, one can also ascertain the headwind and tailwind component for combinations of wind velocities and directions. Refer to paragraph 203 for allowable crosswind components.

3. COVERAGE AND ORIENTATION OF RUNWAYS. The most desirable runway orientation based on wind is the one which has the largest wind coverage and minimum crosswind components. Wind coverage is that percent of time crosswind components are below an acceptable velocity. The desirable wind coverage for an airport is 95 percent, based on the total numbers of weather observations. This value of 95 percent takes into account various factors influencing operations and the economics of providing the coverage. The data collection should be with an understanding of the objective; i.e., to attain 95-percent usability. At many airports, airplane operations are almost nil after dark, and it may be desirable to analyze the wind data on less than a 24-hour observation period. At airports where operations are predominantly seasonal, regard should be given to the wind data for the predominant-use period. At locations where provision of a crosswind runway is impractical due to severe terrain constraints, consideration may be given to increasing operational tolerance to crosswinds by upgrading the airport layout to the next higher airport reference code.

4. ASSEMBLING WIND DATA. The latest and best wind information should always be used to carry out a wind analysis. A record which covers the last 10 consecutive years of wind observations is preferred. Records of lesser duration may be acceptable on a case-by-case basis. In some instances, it may be highly desirable to obtain and assemble wind information for periods of particular significance; e.g., seasonal variations, instrument weather conditions, daytime versus nighttime, and regularly occurring gusts.

a. Data Source. The best sources of wind information is the National Oceanic and Atmospheric Administration, Environmental Data Service (EDS). The EDS's National Climatic Center, located in the Federal Building, Asheville, North Carolina 28801, is the repository of wind information from recording stations throughout the Nation. The Center should be contacted directly to determine the availability of data for a particular site. Refer to appendix 11 for details on the availability and purchase of wind data on disk in the standard FAA wind analysis format for use with the Airport Design Computer Program.

b. Data Costs. The EDS provides wind information at cost. The cost will vary, depending upon the complexity of the information desired, how the data are being stored, and whether the data have been assembled (summarized) previously. The wind summary for the airport site should be formatted with the standard 36 wind quadrants (the EDS standard for noting wind directions since January 1, 1964) and usual speed groupings (see figure A1-3). An existing wind summary of recent vintage is acceptable for analysis purposes if these standard wind direction and speed groupings are used. Figure A1-2 is an example of a typical EDS wind summary.

c. Data Not Available. In those instances when EDS data are not available for the site, it is permissible to develop composite wind data using wind information obtained from two or more nearby recording stations. Composite data are usually acceptable if the terrain between the stations and the site is level or only slightly rolling. If the terrain is hilly or mountainous, composite data may only have marginal validity. In extreme cases it may be necessary to obtain a minimum of 1 year of onsite wind observations. These meager records should be augmented with personal observations (wind-bent trees, interviews with the local populace, etc.) to ascertain if a discernible wind pattern can be established. Airport development should not proceed until adequate wind data are acquired.

5. ANALYZING WIND DATA. One wind analysis procedure uses a scaled graphical presentation of wind information known as a windrose.

a. Drawing the Windrose. The standard windrose (figure A1-3) is a series of concentric circles cut by radial lines. The perimeter of each concentric circle represents the division between successive wind speed groupings. Radial lines are drawn so that the area between each successive pair is centered on the direction of the reported wind.

b. Plotting Wind Data. Each segment of the windrose represents a wind direction and speed grouping corresponding to the wind direction and speed grouping on the EDS summary. The recorded directions and speeds of the wind summary are converted to a percentage of the total recorded observations. Computations are rounded to the nearest one-tenth of 1 percent and entered in the appropriate segment of the windrose. Figure A1-4 illustrates a completed windrose based on data from figure A1-2. Plus (+) symbols are used to indicate direction and speed combinations which occur less than one-tenth of 1 percent of the time.

c. Crosswind Template. A transparent crosswind template is a useful aid in carrying out the windrose analysis. The template is essentially a series of three parallel lines drawn to the same scale as the windrose circles. The allowable crosswind for the runway width establishes the physical distance between the outer parallel lines and the centerline. When analyzing the wind coverage for a runway orientation, the design crosswind limit lines can be drawn directly on the windrose. NOTE: EDS wind directions are recorded on the basis of true north.

d. Analysis Procedure. The purpose of the analysis is to determine the runway orientation which provides the greatest wind coverage within the allowable crosswind limits. This can be readily estimated by rotating the crosswind template about the windrose center point until the sum of the individual segment percentages appearing between the outer "crosswind limit" lines is maximized. It is accepted practice to total the percentages of the segments appearing outside the limit lines and to subtract this number from 100. For analyses purposes, winds are assumed to be uniformly distributed throughout each of the individual segments. Figures A1-5 and A1-6 illustrate the analysis procedure as it would be used in determining the wind coverage for a runway, oriented 105-285, intended to serve all types of airplanes. The wind information is from figure A1-2. Several trial orientations may be needed before the orientation which maximizes wind coverage is found.

6. CONCLUSIONS. The example wind analysis shows that the optimum wind coverage possible with a single runway and a 13-knot crosswind is 97.28 percent. If the analysis had shown that it was not possible to obtain at least 95-percent wind coverage with a single runway, then consideration should be given to provide an additional (crosswind) runway oriented to bring the combined wind coverage of the two runways to at least 95 percent.

7. PRESUMPTIONS. The analysis procedures presume that winds are uniformly distributed over the area represented by each segment of the windrose. The larger the area, the less accurate is this presumption. Therefore, calculations made using nonstandard windrose directions or speeds result in a derivation of wind coverage (and its associated justification for a crosswind runway) which is questionable.

8. COMPUTER WIND ANALYSIS. Another wind analysis procedure uses a computer program. Figures A1-7, A1-8, and A1-9 are computer printouts based on the data from figure A1-2. The computed generated coverage in this example is 96.75 percent. Figures A1-10 and A1-11 are Lotus 1-2-3 cell-equations used to generate figures A1-7, A1-8, and A1-9 on an IBM PC compatible computer. Appendix 11 gives details on availability of another wind analysis computer program.

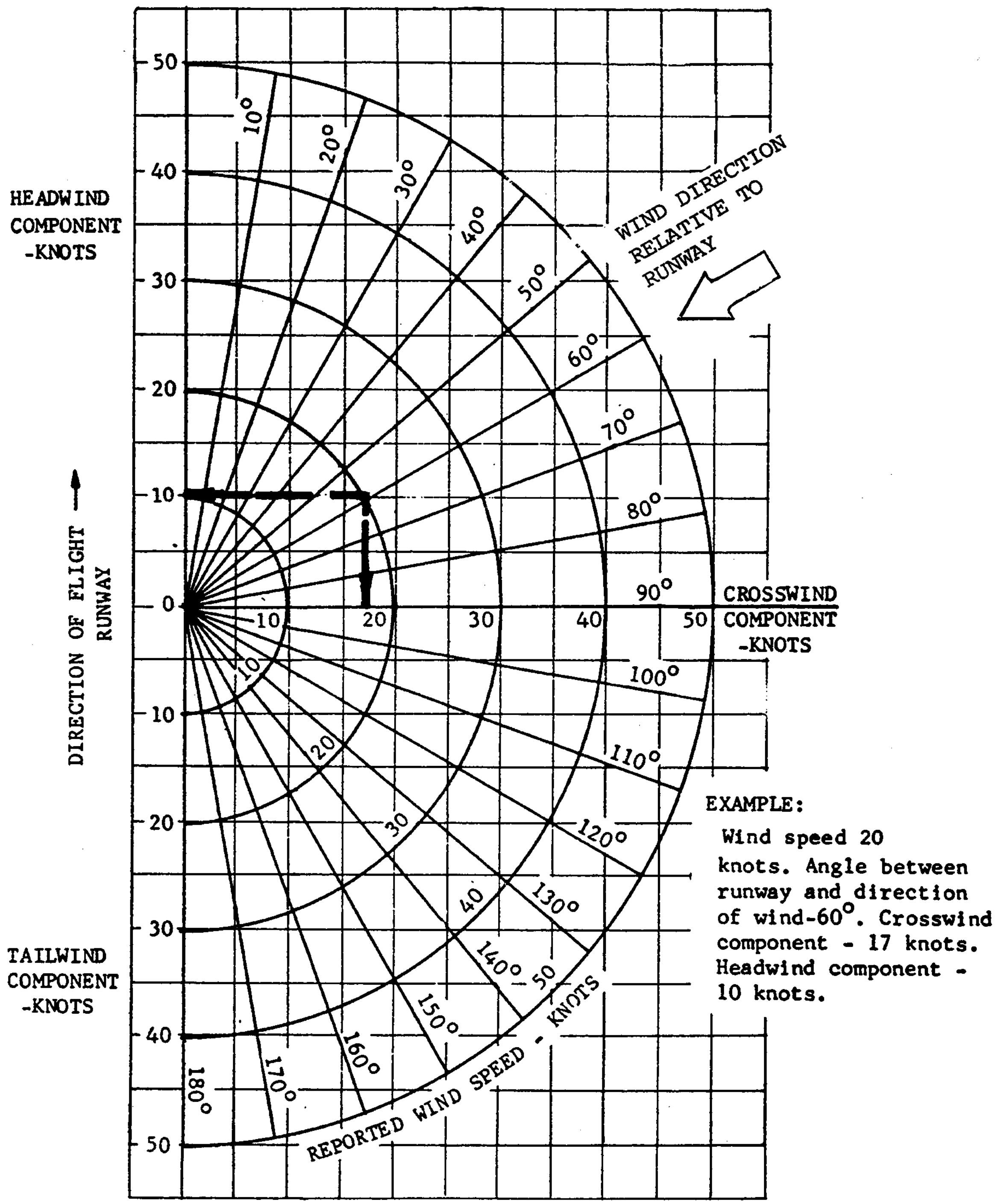


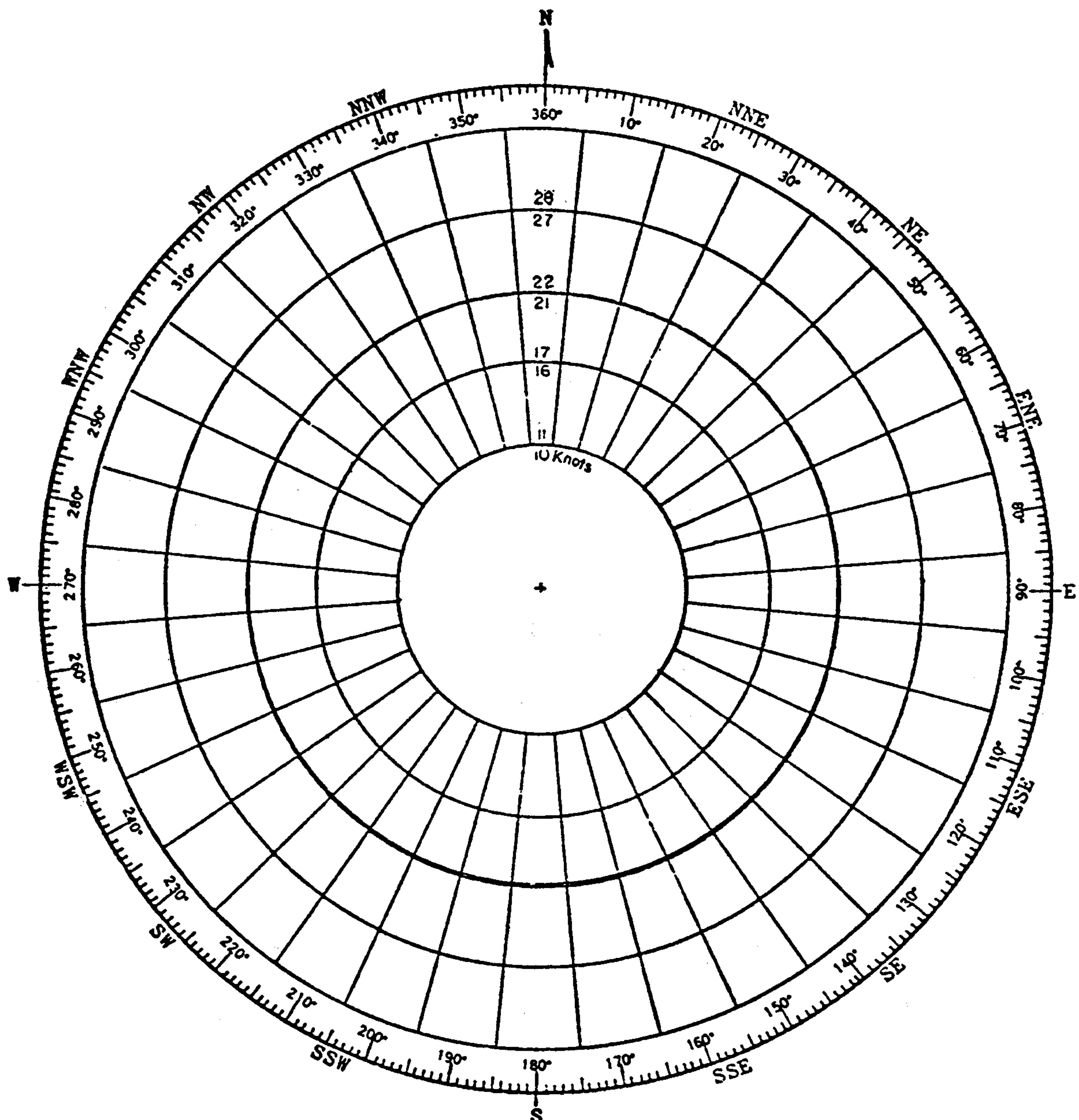
Figure A1-1. Wind vector diagram

WIND DIRECTION VERSUS WIND SPEED

STATION: Anywhere, USA   HOURS: 24 Observations/Day   PERIOD OF RECORD: 1964-1973

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED									TOTAL	AVERAGE SPEED	
	KNOTS 0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41 OVER		KNOTS	MPH
	MPH 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER			
01	469	842	568	212						2091	6.2	7.1
02	568	1263	820	169						2820	6.0	6.9
03	294	775	519	73	9					1670	5.7	6.6
04	317	872	509	62	11					1771	5.7	6.6
05	268	861	437	106						1672	5.6	6.4
06	357	534	151	42	8					1092	4.9	5.6
07	369	403	273	84	36	10				1175	6.6	7.6
08	158	261	138	69	73	52	41	22		814	7.6	8.8
09	167	352	176	128	68	59	21			971	7.5	8.6
10	119	303	127	180	98	41	9			877	9.3	10.7
11	323	586	268	312	111	23	28			1651	7.9	9.1
12	618	1397	624	779	271	69	21			3779	8.3	9.6
13	472	1375	674	531	452	67				3571	8.4	9.7
14	647	1377	574	281	129					3008	6.2	7.1
15	338	1093	348	135	27					1941	5.6	6.4
16	560	1399	523	121	19					2622	5.5	6.3
17	587	883	469	128	12					2079	5.4	6.2
18	1046	1984	1068	297	83	18				4496	5.8	6.7
19	499	793	586	241	92					2211	6.2	7.1
20	371	946	615	243	64					2239	6.6	7.6
21	340	732	528	323	147	8				2078	7.6	8.8
22	479	768	603	231	115	38	19			2253	7.7	8.9
23	187	1008	915	413	192					2715	7.9	9.1
24	458	943	800	453	96	11	18			2779	7.2	8.2
25	351	899	752	297	102	21	9			2431	7.2	8.2
26	368	731	379	208	53					1739	6.3	7.2
27	411	748	469	232	118	19				1997	6.7	7.7
28	191	554	276	287	118					1426	7.3	8.4
29	271	642	548	479	143	17				2100	8.0	9.3
30	379	873	526	543	208	34				2563	8.0	9.3
31	299	643	597	618	222	19				2398	8.5	9.8
32	397	852	521	559	158	23				2510	7.9	9.1
33	236	721	324	238	48					1567	6.7	7.7
34	280	916	845	307	24					2372	6.9	7.9
35	252	931	918	487	23					2611	6.9	7.9
36	501	1568	1381	569	27					4046	7.0	8.0
00	7729									7729	0.0	0.0
TOTAL	21676	31828	19849	10437	3357	529	166	22		87864	6.9	7.9

Figure A1-2. Typical environmental data service wind summary



WIND SPEED DIVISIONS		RADIUS OF CIRCLE (KNOTS)
KNOTS	M.P.H.	
0 - 3.5	0 - 3.5	* 3.5 Units
3.5 - 6.5	3.5 - 7.5	* 6.5 "
6.5 - 10.5	7.5 - 12.5	10.5 - "
10.5 - 16.5	12.5 - 18.5	16.5 - "
16.5 - 21.5	18.5 - 24.5	21.5 - "
21.5 - 27.5	24.5 - 31.5	27.5 - "
27.5 - 33.5	31.5 - 38.5	*33.5 - "
33.5 - 40.5	38.5 - 46.5	*40.5 - "
40.5 - over	46.5 - over	

*May not be needed for most windrose analyses.

Figure A1-3. Windrose blank showing direction and divisions

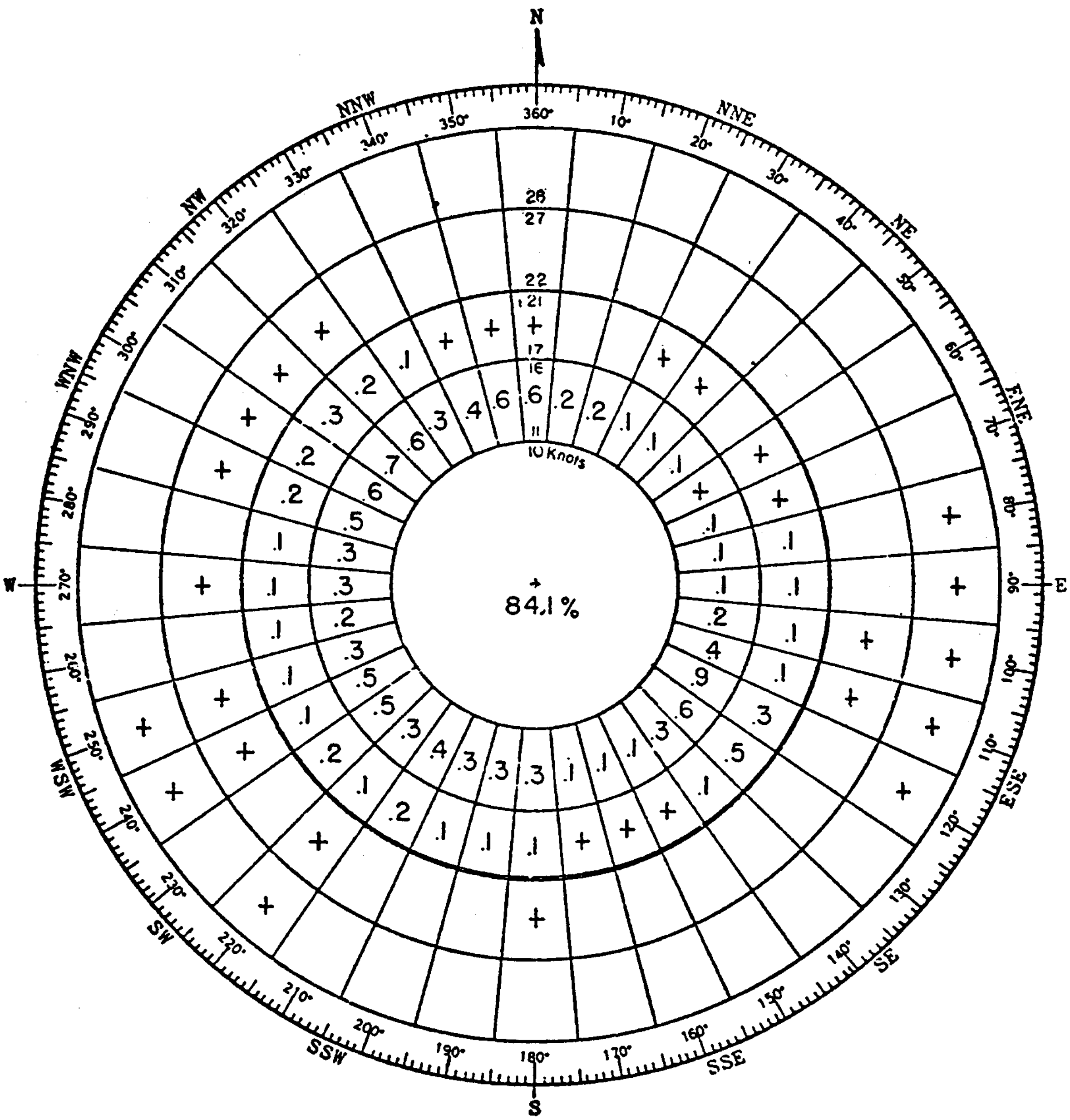
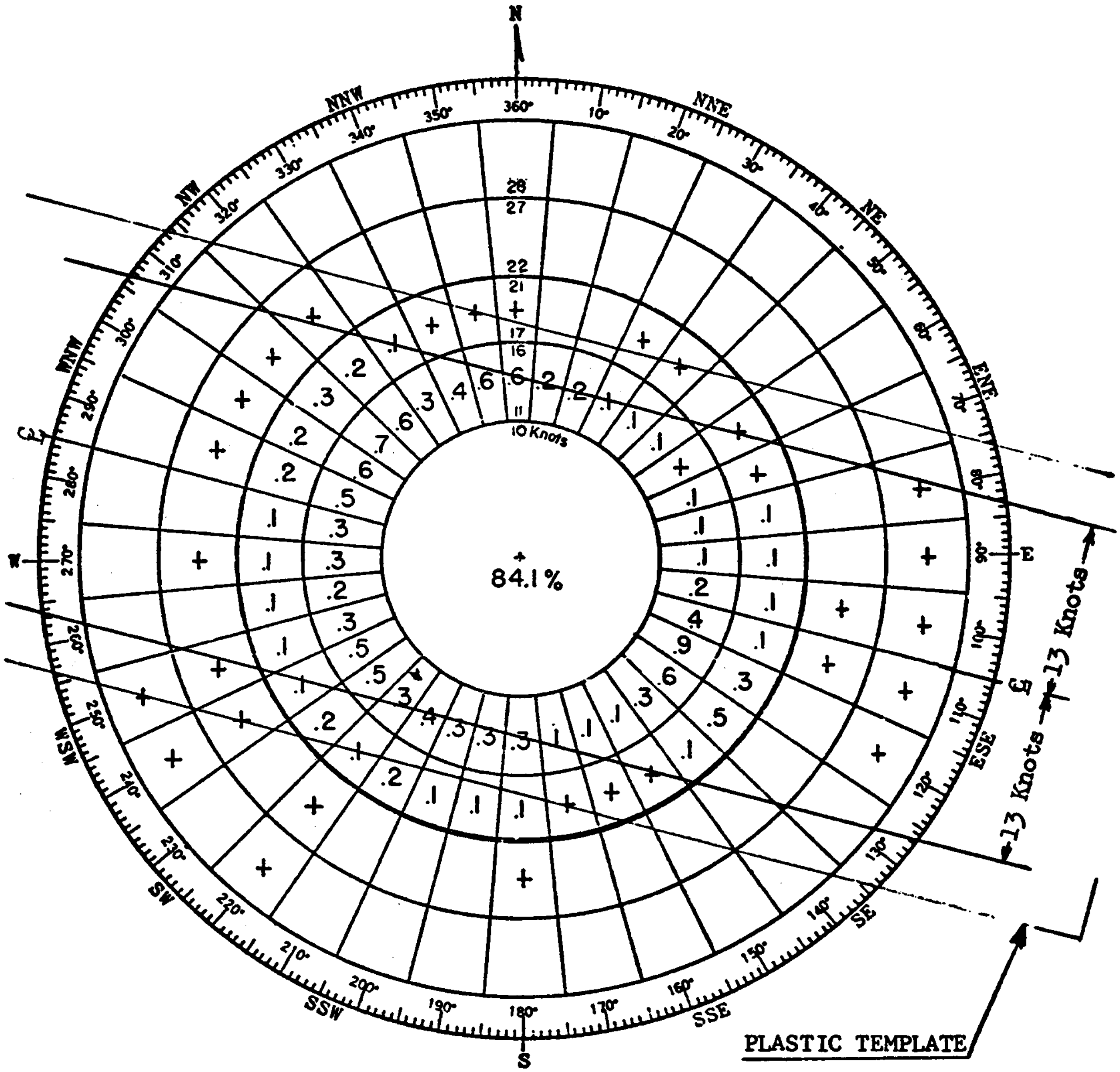


Figure A1-4. Completed windrose using figure A1-2 data



A runway oriented 105°-285° (true) would have 2.72% of the winds exceeding the design crosswind/crosswind component of 13 knots.

Figure A1-5. Windrose analysis

DIRECTION	ESTIMATED AREA NOT INCLUDED 11-16	17-21	22-27	28+
10	.12			
20	.12			
30	.05	+		
40	.04	+		
50	.01			
60		+		
70				
80			.01	+
90				
100				
110				
120				
130			.01	
140		.01		
150		+		
160	.01	+		
170	.04	+		
180	.14	.10	+	
190	.16	.10		
200	.16	.10		
210	.20	.20	+	
220	.11	.10	+	+
230	.03	.19		
240		.05	+	+
250		.01	+	+
260				
270				
280				
290				
300				
310				
320		.01	+	
330		.05		
340	.04	+		
350	.25	+		
360	.30	+		
SUM	1.78	.92	.02	+

1.78
.92
.02
2.72

100.00
2.72
97.28

100.00 - SUM = Coverage

100.00 - 2.72 =97.28% Coverage

Figure A1-6. Windrose analysis--estimating area not included

```
September 29, 1989        WIND OBSERVATIONS
STATION:                 ANYWHERE, USA
RUNWAY ORIENTATION:         105 DEGREE
CROSSWIND COMPONENT:         13 KNOTS
WIND COVERAGE:           96.746 %
```

DIRECTION	WIND SPEED (KNOTS)									
	0	4	7	11	17	22	28	34	41	
	3	6	10	16	21	27	33	40	99	
1				212						
2				169						
3				73	9					
4				62	11					
5				106						
6				42	8					
7				84	36	10				
8				69	73	52	41	22		
9				128	68	59	21			
10				180	98	41	9			
11				312	111	23	28			
12				779	271	69	21			
13				531	452	67				
14				281	129					
15				135	27					
16				121	19					
17				128	12					
18				297	83	18				
19				241	92					
20				243	64					
21				323	147	8				
22				231	115	38	19			
23				413	192					
24				453	96	11	18			
25				297	102	21	9			
26				208	53					
27				232	118	19				
28				287	118					
29				479	143	17				
30				543	208	34				
31				618	222	19				
32				559	158	23				
33				238	48					
34				307	24					
35				487	23					
36				569	27					
0	21676	31828	19849							
TOTAL:	21676	31828	19849	10437	3357	529	166	22	0	87864

Figure A1-7. Computer printout page 1

AREA NOT INCLUDED

STATION: ANYWHERE, USA
RUNWAY ORIENTATION: 105 DEGREE
CROSSWIND COMPONENT: 13 KNOTS

DIRECTION	WIND SPEED (KNOTS)										
	0 3.5	3.5 6.5	6.5 10.5	10.5 16.5	16.5 21.5	21.5 27.5	27.5 33.5	33.5 40.5	40.5 99.5		
1				0.6212	1	1	1	1	1	13.200	13
2				0.6212	1	1	1	1	1	13.200	13
3				0.5532	1	1	1	1	1	13.834	13.200
4				0.3986	1	1	1	1	1	15.011	13.834
5				0.1185	0.9910	1	1	1	1	16.970	15.011
6					0.6265	1	1	1	1	20.224	16.970
7					0.0385	0.7588	1	1	1	26	20.224
8						0.0242	0.4669	0.9150	1	38.009	26
9								0.0243	0.8525	74.864	38.009
10									0	1E+51	74.864
11									0	1E+51	74.864
12								0.0243	0.8525	74.864	38.009
13						0.0242	0.4669	0.9150	1	38.009	26
14					0.0385	0.7588	1	1	1	26	20.224
15					0.6265	1	1	1	1	20.224	16.970
16				0.1185	0.9910	1	1	1	1	16.970	15.011
17				0.3986	1	1	1	1	1	15.011	13.834
18				0.5532	1	1	1	1	1	13.834	13.200
19				0.6212	1	1	1	1	1	13.200	13
20				0.6212	1	1	1	1	1	13.200	13
21				0.5532	1	1	1	1	1	13.834	13.200
22				0.3986	1	1	1	1	1	15.011	13.834
23				0.1185	0.9910	1	1	1	1	16.970	15.011
24					0.6265	1	1	1	1	20.224	16.970
25					0.0385	0.7588	1	1	1	26	20.224
26						0.0242	0.4669	0.9150	1	38.009	26
27								0.0243	0.8525	74.864	38.009
28									0	1E+51	74.864
29									0	1E+51	74.864
30								0.0243	0.8525	74.864	38.009
31						0.0242	0.4669	0.9150	1	38.009	26
32					0.0385	0.7588	1	1	1	26	20.224
33					0.6265	1	1	1	1	20.224	16.970
34				0.1185	0.9910	1	1	1	1	16.970	15.011
35				0.3986	1	1	1	1	1	15.011	13.834
36				0.5532	1	1	1	1	1	13.834	13.200

Figure A1-8. Computer printout page 2

% WIND NOT COVERED

STATION: ANYWHERE, USA
RUNWAY ORIENTATION: 105 DEGREE
CROSSWIND COMPONENT: 13 KNOTS

DIRECTION	WIND SPEED (KNOTS)									TOTAL:
	0 3.5	3.5 6.5	6.5 10.5	10.5 16.5	16.5 21.5	21.5 27.5	27.5 33.5	33.5 40.5	40.5 99.5	
1				0.1498	0	0	0	0	0	0.1498
2				0.1194	0	0	0	0	0	0.1194
3				0.0459	0.0102	0	0	0	0	0.0562
4				0.0281	0.0125	0	0	0	0	0.0406
5				0.0142	0	0	0	0	0	0.0142
6					0.0057	0	0	0	0	0.0057
7					0.0015	0.0086	0	0	0	0.0102
8						0.0014	0.0217	0.0229	0	0.0461
9								0	0	0
10										0
11										0
12								0	0	0
13						0.0018	0	0	0	0.0018
14					0.0056	0	0	0	0	0.0056
15					0.0192	0	0	0	0	0.0192
16				0.0163	0.0214	0	0	0	0	0.0377
17				0.0580	0.0136	0	0	0	0	0.0717
18				0.1870	0.0944	0.0204	0	0	0	0.3019
19				0.1704	0.1047	0	0	0	0	0.2751
20				0.1718	0.0728	0	0	0	0	0.2446
21				0.2033	0.1673	0.0091	0	0	0	0.3797
22				0.1048	0.1308	0.0432	0.0216	0	0	0.3005
23				0.0557	0.2165	0	0	0	0	0.2722
24					0.0684	0.0125	0.0204	0	0	0.1014
25					0.0044	0.0181	0.0102	0	0	0.0328
26						0	0	0	0	0
27								0	0	0
28										0
29										0
30								0	0	0
31						0.0005	0	0	0	0.0005
32					0.0069	0.0198	0	0	0	0.0267
33					0.0342	0	0	0	0	0.0342
34				0.0414	0.0270	0	0	0	0	0.0684
35				0.2209	0.0261	0	0	0	0	0.2471
36				0.3582	0.0307	0	0	0	0	0.3890
TOTAL:	0	0	0	1.9459	1.0748	0.1357	0.0741	0.0229	0	3.2537

Figure A1-9. Computer printout page 3

Lines starting with + are worksheet format instructions.
Lines starting with a cell address are cell-formulas.
Lines starting with COPY and DATA FILL are Lotus 1-2-3 commands.

To run the program fill RANGE(D2..D4) with airport data (airport name D2, runway orientation D3, and crosswind component in knots D4) and fill RANGE(B11..J47) with wind data.

```
+ Set Global Column-Width at 7

E1: 'WIND OBSERVATIONS
A2: 'STATION:
A3: 'RUNWAY ORIENTATION:
E3: 'DEGREE
A4: 'CROSSWIND COMPONENT:
E4: 'KNOTS
A5: 'WIND COVERAGE:
D5: 100-L148
E5: '%
A7: 'DIRECTION
E7: 'WIND SPEED (KNOTS)
B8: 0
C8: 4
D8: 7
E8: 11
F8: 17
G8: 22
H8: 28
I8: 34
J8: 41
K8: 100
A9: '
B9: 3
C9: 6
D9: 10
E9: 16
F9: 21
G9: 27
H9: 33
I9: 40
J9: 99
DATA FILL RANGE(A11..A46)  WITH 1 TO 36
A47: 0
A48: 'TOTAL:
B48: @SUM(B11..B47)
COPY CELL B48 TO RANGE(B48..J48)
K48: @MAX(1,@SUM(B48..J48))
A50: |::
```

Figure A1-10. Lotus cell-formulas page 1

```
E51: 'AREA NOT INCLUDED
A52: +A2
COPY CELL A52 TO RANGE(A52..A54)
D52: +D2
COPY CELL D52 TO RANGE(D53..E54)
A57: +A7
E57: +E7
B58: (A9+B8)/2
COPY CELL B58 TO RANGE(B58..J58)
B59: (B9+C8)/2
COPY CELL B59 TO RANGE(B59..J59)
A61: +A11
COPY CELL A61 TO RANGE(A61..A96)
B61: @IF($K61<=B$58,1,@IF($L61>B$59,$A$9,(B$59^2-$K61*$L61+
     @IF($K61<B$59,0,$L61*($K61-B$59)^2/($K61-$L61))-
     @IF($L61>B$58,0,$K61*(B$58-$L61)^2/($K61-$L61)))/(B$59^2-B$58^2)))
COPY CELL B61 TO RANGE(B61..J96)
K61: @MAX($D$4/(@MAX(@ABS(@SIN(($D$3-A61*10+5)*@PI/180)),1.0000000E-50)),
     $D$4/(@MAX(@ABS(@SIN(($D$3-A61*10-5)*@PI/180)),1.0000000E-50)))
COPY CELL K61 TO RANGE(K61..K96)
L61: @MIN($D$4/(@MAX(@ABS(@SIN(($D$3-A61*10+5)*@PI/180)),1.0000000E-50)),
     $D$4/(@MAX(@ABS(@SIN(($D$3-A61*10-5)*@PI/180)),1.0000000E-50)))
COPY CELL L61 TO RANGE(L61..L96)
A100: |::
E101: '% WIND NOT COVERED
A102: +A2
COPY CELL A102 TO RANGE(A102..A104)
D102: +D2
COPY CELL D102 TO RANGE(D103..E104)
A107: +A7
E107: +E7
L107: 'TOTAL:
B108: +B58
COPY CELL B108 TO RANGE(B108..J109)
A111: +A61
COPY CELL A111 TO RANGE(A111..A146)
B111: @IF(B61=0,$A$9,100*(B61*B11)/$K$48)
COPY CELL B111 TO RANGE(B111..J146)
L111: @SUM(B111..J111)
COPY CELL L111 TO RANGE(L111..L146)
A148: 'TOTAL:
B148: @SUM(B111..B146)
COPY CELL B148 TO RANGE(B148..J148)
L148: @SUM(L111..L146)
A150: |::
```

Figure A1-11. Lotus cell-formulas page 2

Appendix 2. THRESHOLD SITING REQUIREMENTS

1. PURPOSE. This appendix contains guidance on locating thresholds to meet approach obstacle clearance requirements.

2. APPLICATION.

a. The threshold should be located at the beginning of the full-strength runway pavement or runway surface. However, displacement of the threshold may be required when an object that obstructs the airspace required for landing airplanes is beyond the airport owner's power to remove, relocate, or lower. Thresholds may also be displaced for environmental considerations, such as noise abatement, or to provide the standard RSA and ROFA lengths.

b. When a hazard to air navigation exists, the amount of displacement of the threshold should be based on the operational requirements of the most demanding airplanes. The standards in this appendix minimize the loss of operational use of the established runway. These standards reflect FAA policy of maximum utilization and retention of existing paved areas on airports.

c. Displacement of a threshold reduces the length of runway available for landings. Depending on the reason for displacement of the threshold, the portion of the runway behind a displaced threshold may be available for takeoffs in either direction and landings from the opposite direction. Refer to appendix 14 for additional information.

3. LIMITATIONS.

a. These standards should not be interpreted as an FAA blanket endorsement of the alternative to displace or relocate a runway threshold. Threshold displacement or relocation should be undertaken only after a full evaluation reveals that displacement or relocation is the only practical alternative.

b. The standards in this appendix are not applicable for identifying objects affecting navigable airspace (FAR Part 77) or zoning to limit the height of objects around airports (AC 150/5190-4).

4. EVALUATION CONSIDERATIONS.

a. When a penetration to a surface defined in paragraph 5 (threshold siting surfaces) exists, one or more of the following actions is required:

(1) The object is removed or lowered to preclude penetration of applicable threshold siting surfaces;

(2) The threshold is displaced to preclude object penetration of applicable threshold siting surfaces, with a resulting shorter landing distance; or

(3) Visibility minimums are raised.

b. Relevant factors for evaluation include:

(1) Types of airplanes which will use the runway and their performance characteristics.

(2) Operational disadvantages associated with accepting higher landing minimums.

(3) Cost of removing, relocating, or lowering the object.

(4) Effect of the reduced available landing length when the runway is wet or icy.

(5) Cost of extending the runway if insufficient runway length would remain as a result of displacing the threshold. The environmental and public acceptance aspects of a runway extension need also be evaluated under this consideration.

(6) Cost and feasibility of relocating visual and electronic approach aids, such as threshold lights, visual approach slope indicator, runway end identification lights, localizer, glide slope (to provide a threshold crossing height of not more then 60 feet (18 m)), approach lighting system, and runway markings.

(7) Effect of the threshold change on noise abatement.

5. LOCATING, DISPLACING, OR RELOCATING THE THRESHOLD. The standard shape, dimensions, and slope of the surface used for locating a threshold is dependent upon the type of aircraft operations currently conducted or forecasted, the landing visibility minimums desired, and the types of instrumentation available or planned for that runway end.

a. For Approach End of Runways Expected to Serve Small Airplanes With Approach Speeds Less Than 50 Knots.

(1) No object should penetrate a surface that starts at the threshold and at the elevation of the runway centerline at the threshold and slopes upward from the threshold at a slope 15 (horizontal) to 1 (vertical).

(2) In the plan view, the centerline of this surface extends 3,000 feet (900 m) along the extended runway centerline. This surface extends laterally 60 feet (18 m) on each side of the centerline at the threshold and increases in width to 150 feet (45 m) at a point 500 feet (150 m) from the threshold; thereafter, it extends laterally 150 feet (45 m) on each side of the centerline. (See figures A2-1 and A2-2.)

b. For Approach End of Runways, Including STOL Runways, Expected to Serve Small Airplanes With Approach Speeds of 50 Knots or More.

(1) No object should penetrate a surface that starts at the threshold and at the elevation of the runway centerline at the threshold and slopes upward from the threshold at a slope 20 (horizontal) to 1 (vertical).

(2) In the plan view, the centerline of this surface extends 5,000 feet (1 530 m) along the extended runway centerline. This surface extends laterally 125 feet (38 m) on each side of the centerline at the threshold and increases in width to 350 feet (110 m) at a point 2,250 feet (690 m) from the threshold; thereafter, it extends laterally 350 feet (110 m) on each side of the centerline. (See figures A2-1 and A2-2.)

c. For Approach End of Runways, Including STOL Runways, Expected to Serve Large Airplanes.

(1) No object should penetrate a surface that starts at the threshold and at the elevation of the runway centerline at the threshold and slope upward from the threshold at a slope 20 (horizontal) to 1 (vertical).

(2) In the plan view, the centerline of this surface extends 10,000 feet (3 000 m) along the extended runway centerline. This surface extends laterally 200 feet (60 m) on each side of the centerline at the threshold and increases in width to 500 feet (150 m) at a point 1,500 feet (450 m) from the threshold; thereafter, it extends laterally 500 feet (150 m) on each side of the centerline. (See figures A2-1 and A2-2.)

d. For Approach End of Runways, Except STOL Runways, Expected to Accommodate Instrument Approaches Having Visibility Minimums Lower Than 1 Mile.

(1) No object should penetrate a surface that starts 200 feet (60 m) out from the threshold and at the elevation of the runway centerline at the threshold and slopes upward from the starting point at a slope of 20 (horizontal) to 1 (vertical).

(2) In the plan view, the centerline of this surface extends 10,000 feet (3 000 m) along the extended runway centerline. This surface extends laterally 500 feet (150 m) on each side of the centerline at the starting point and increases in width to 2,000 feet (600 m) at the far end of this surface. (See figures A2-1 and A2-2.)

(3) If the instrument approach procedure utilizes an offset localizer with an offset angle of 3 degrees or less, the above surface is centered upon the final approach course rather than the extended runway centerline. (See figure A2-3.)

e. For Approach End of Runways, Except STOL Runways, Expected to Accommodate Instrument Approaches Having Visibility Minimums Lower Than 3/4 Mile.

(1) No object should penetrate a surface that starts 200 feet (60 m) out from the threshold and at the elevation of the runway centerline at the threshold and slopes upward from the starting point at a slope of 34 (horizontal) to 1 (vertical).

(2) In the plan view, the centerline of this surface extends 10,000 feet (3 000 m) along the extended runway centerline. This surface extends laterally 500 feet (150 m) on each side of the centerline at the starting point and increases in width to 2,000 feet (600 m) at the far end of this surface. (See figures A2-1 and A2-2.)

(3) If the instrument approach procedure utilizes an offset localizer with an offset angle of 3 degrees or less, the above surface is centered upon the final approach course rather than the extended runway centerline. (See figure A2-3.)

f. For Approach End of Runways Expected to Accommodate Category II Approach Minimums. Criteria are set forth in AC 120-29.

g. For STOL Runways. Criteria are set forth in Appendix 4, MLS STOL Procedures, of Order 8260.30 and the preceding paragraphs.

RUNWAY TYPE	DIMENSIONAL STANDARDS FEET (METERS)					
	A	B	C	D	E	SLOPE
a. Approach end of runways expected to serve small airplanes with approach speeds less than 50 knots.	0	60 (18)	150 (45)	500 (150)	2,500 (750)	15:1
b. Approach end of runways, including STOL runways, expected to serve small airplanes with approach speeds of 50 knots or more.	0	125 (38)	350 (110)	2,250 (690)	2,750 (840)	20:1
c. Approach end of runways, including STOL runways, expected to serve large airplanes.	0	200 (60)	500 (150)	1,500 (450)	8,500 (2 550)	20:1
d. Approach end of runways, except STOL runways, having visibility minimums lower than 1 mile.	200 (60)	500 (150)	2,000 (600)	10,000 (3 000)	0	20:1
e. Approach end of runways, except STOL runways, having visibility minimums lower than 3/4 mile.	200 (60)	500 (150)	2,000 (600)	10,000 (3 000)	0	34:1
f. Approach runway ends having Category II approach minimums.	The criteria are set forth in AC 120-29.					
g. STOL runways.	The criteria are set forth in appendix 4 of Order 8260.30.					

The letters are keyed to those shown on figures A2-2 and A2-3.

Figure A2-1. Dimensional standards for locating thresholds

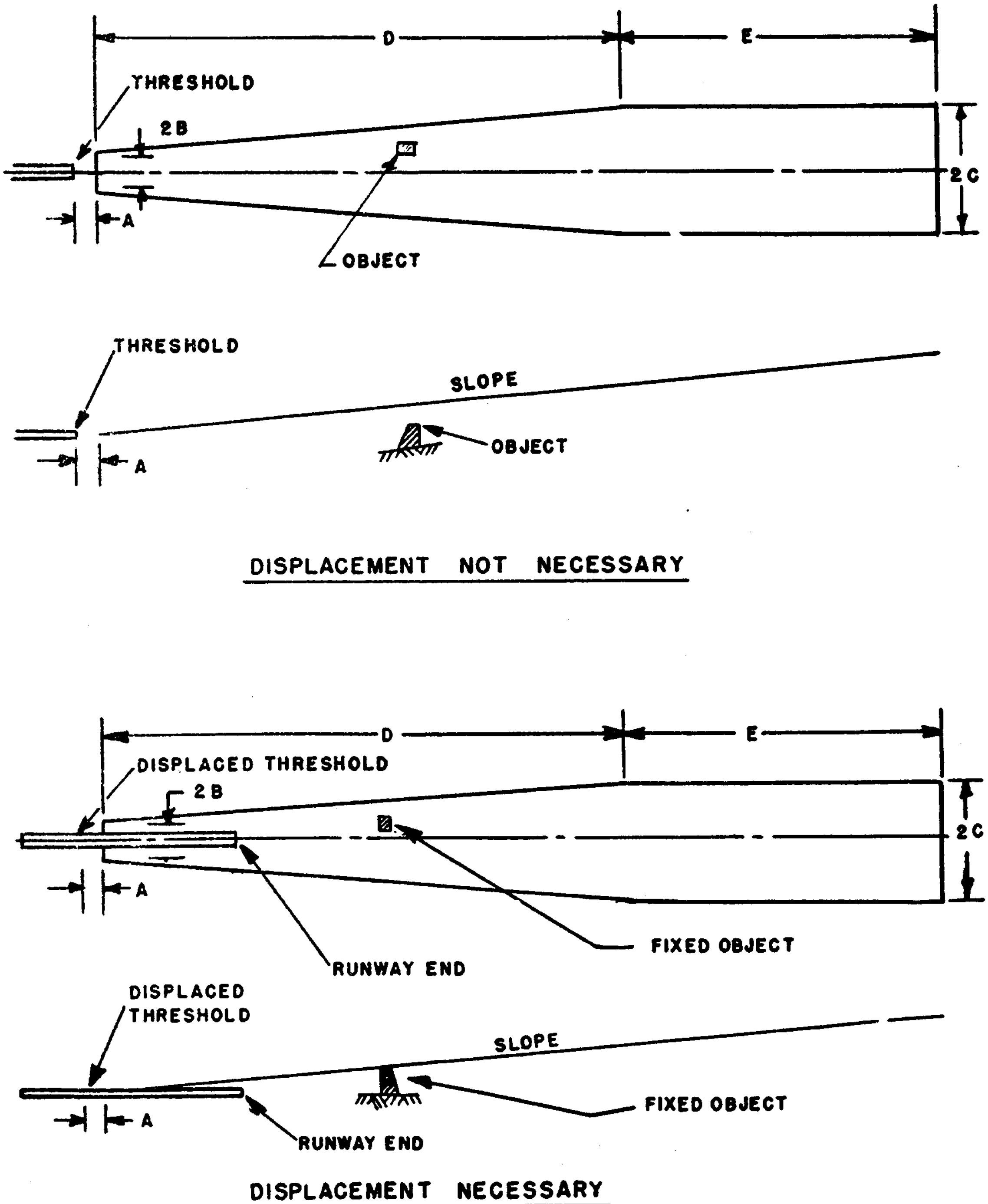


Figure A2-2. Approach slopes

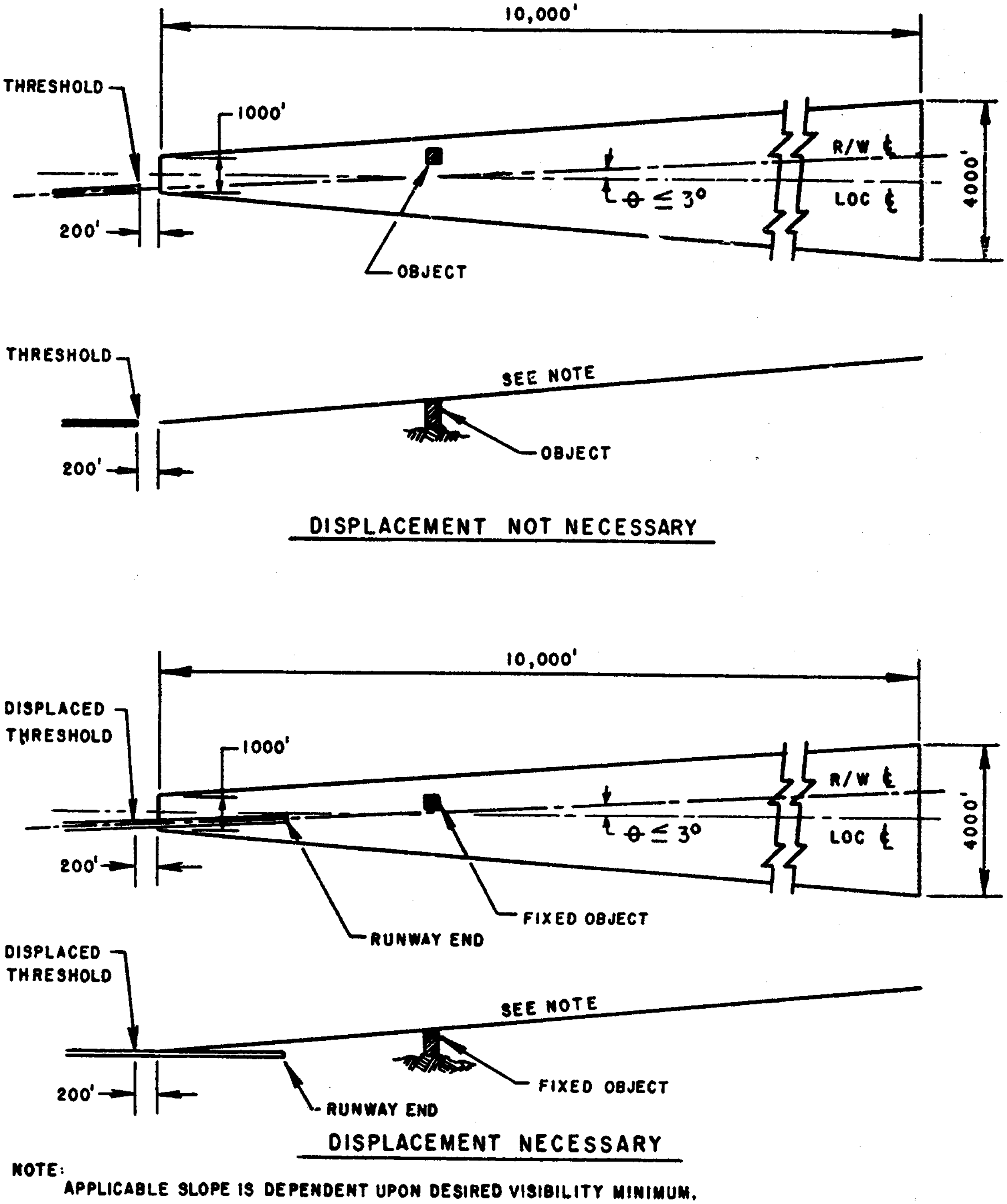


Figure A2-3. Approach slopes--offset localizer

Appendix 3. AIRPORT REFERENCE POINT

1. DISCUSSION.

a. The airport reference point (ARP) geographically locates the airport horizontally. The ARP is normally not monumented or physically marked on the ground. The computation of this point uses only runway length.

b. Meaningful airport reference point computations use the ultimate runway lengths proposed for development. These computations do not use closed or abandoned areas. The FAA approved airport layout plan shows the ultimate development. If there is no airport layout plan, the ultimate runway lengths are the existing runways plus those which have airspace approval, less closed or abandoned areas.

c. The ARP is computed or recomputed as infrequently as possible. The only time that a recomputation is needed is when the proposed ultimate development is changed.

2. SAMPLE COMPUTATION. The following procedure determines the location of the airport reference point used in FAR Part 77 studies.

a. Establish two base lines perpendicular to each other as shown in Figure A3-1. Let the northerly base line be known as B and the westerly as A.

b. Establish the midpoint of each runway.

c. Determine the perpendicular distance from the base lines to the midpoints.

d. Calculate the moment of areas for each base line as shown in Figure A3-2.

e. Divide each moment of area by the sum of areas to determine distance of the ARP from each base line.

f. The location is converted into latitude and longitude.

3. ACCURACY. The latitude and longitude should be to the nearest second. Installation of navigational aids may need coordinates to the nearest tenth of a second. Coordinate with the appropriate FAA Airway Facilities field office to ascertain the need for accuracy closer than the nearest second.

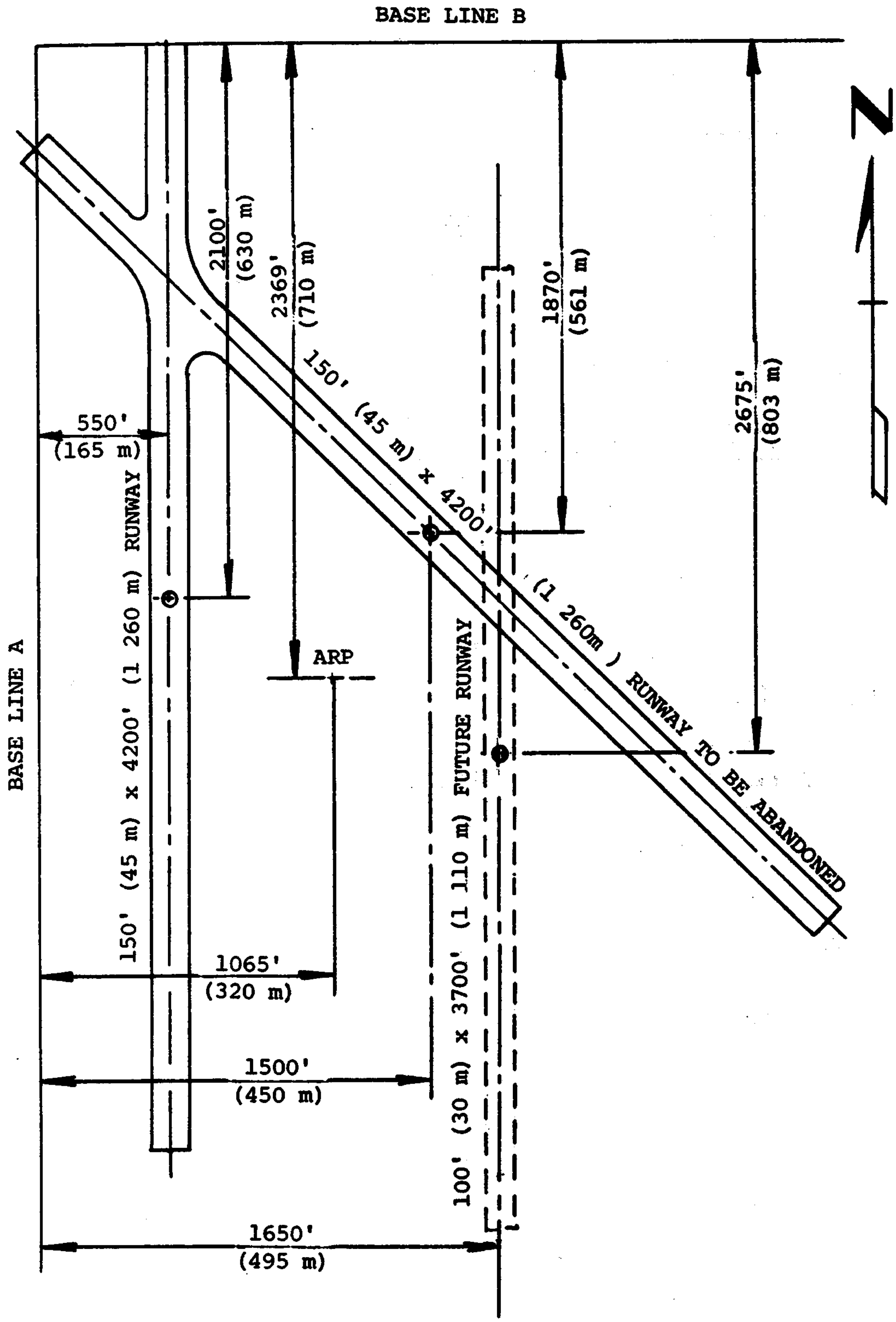


Figure A3-1. Sample layout

U.S. Customary Units

BASE LINE A:

4,200	x	550	=	2,310,000
3,700	x	1,650	=	6,105,000
7,900				8,415,000

$$= \frac{8,415,000}{7,900} = 1,065'$$

BASE LINE B:

4,200	x	2,100	=	8,820,000
3,700	x	2,675	=	9,897,500
7,900				18,717,500

$$= \frac{18,717,500}{7,900} = 2,369'$$

Metric Units

BASE LINE A:

1 266	x	165	=	207 900
1 110	x	495	=	549 450
2 370				757 350

$$= \frac{757\ 350}{2\ 370} = 320 \text{ m}$$

BASE LINE B:

1 266	x	630	=	793 800
1 110	x	803	=	891 330
2 370				1 685 130

$$= \frac{1\ 685\ 130}{2\ 370} = 710 \text{ m}$$

Note: Since diagonal runway is to be abandoned, it is not used in the computation.

Figure A3-2. Sample computation - airport reference point

Appendix 4. COMPASS CALIBRATION PAD

1. PURPOSE. This appendix provides guidelines for the design, location and construction of a compass calibration pad and basic information concerning its use in determining the deviation error in an aircraft magnetic compass.

2. BACKGROUND.

a. An aircraft magnetic compass is a navigation instrument with certain inherent errors resulting from the nature of its construction. All types of magnetic compasses indicate direction with respect to the earth's magnetic field. This is true even for the gyro-stabilized and/or fluxgate compasses. Aircraft navigation is based on applying the appropriate angular corrections to the magnetic reading in order to obtain the true heading.

b. The aircraft magnetic compass should be checked following pertinent aircraft modifications and on a frequent, routine schedule. One method of calibrating the compass is to use a compass calibration pad to align the aircraft on known magnetic headings and make adjustments to the compass and/or placard markings to indicate the required corrections. There are other methods available for calibrating a magnetic compass, but for small aircraft the method outlined herein is normally used.

3. APPLICATION.

a. The process of aligning an aircraft on known magnetic headings for the purpose of determining the degree of error in the magnetic compass is commonly referred to as "swinging the compass." The technique which should be used is as follows:

(1) Place the aircraft on a compass calibration pad.

(2) Place the aircraft in level flying position.

(3) Remove compensating magnets from chambers or reset the fixed compensating magnets to neutral position, whichever is applicable, before swinging.

(4) Check indicator for fluid level and cleanliness. If fluid is required, the compass is defective.

(5) Check the pivot friction of the indicator by deflecting the card with a small magnet. The card should rotate freely in a horizontal plane.

(6) If a radio is used in the aircraft, there should be corrections noted for "radio on" and "radio off" conditions.

(7) Align the aircraft with the north magnetic heading and make the indicated reading correspond to the actual magnetic reading by use of the compensating magnets. Repeat for the east magnetic heading. Then place on south and west magnetic headings and remove half of indicated error by adjusting compensators. Engine(s) should be running.

(8) Turn the aircraft on successive 30-degree headings through 360 degrees. Placards should be marked to indicate correction at each 30-degree heading showing "radio on" and "radio off" corrections.

b. Calibration and adjustment of remote indicating gyro compasses, polar path compasses, and other systems of this type should be by a qualified instrument technician.

4. DESIGN OF COMPASS CALIBRATION PAD. The design details shown in this appendix should be considered as guidance only and variations of these designs are acceptable provided the general requirements are met.

a. The compass calibration pad provides a series of 12 radials, either painted on with nonmetallic paint or inlaid in the surface of the calibration pad, extending toward predetermined magnetic directions every 30 degrees beginning with magnetic north. Each radial should be marked with three separate magnetic headings; one at the end of the radial indicating the direction along which each line lies; and one on each side of the line which indicates the magnetic heading of the aircraft when it is oriented at 90 degrees to the radial. Markings facing the pilot must correspond to the airplane's heading when traveling in that direction. The markings must be large enough to be easily read from the aircraft cockpit as the radial is being approached. The last zero may be dropped from the heading designation. Figure A4-1 shows a layout of markings.

b. Figures A4-2 and A4-3 depict suggested types of calibration pads. Type I, as shown in figure A4-2, can be either rigid or flexible pavement construction. Type II, as shown in figure A4-3, is applicable only to rigid pavements. The pavement thickness of either type shall be as required to support the user aircraft in a critical area in accordance with AC 150/5320-6. The concrete pavements, joint type, and spacing shall conform to standard practices, without no magnetic materials. Therefore, dowels (where required) shall be of aluminum, brass, or bronze, rather than steel.

c. Make the size of the calibration pad compatible with the requirements of the user aircraft. For small airplanes make the radius of the pad 50 feet (15 m); for basic transports make the radius 60 feet (18 m); for large two- and three-engine jets, other than basic transports, and all large propeller-driven airplanes make the radius 80 feet (24 m); and for large four-engine jets, other than basic transports, make the radius 110 feet (33 m). For aircraft over 300,000 pounds (136 000 kg), an analysis of the turning area required for the aircraft will be necessary to determine adaptability to the dimensions specified herein.

d. The Type II compass calibration pad shown in figure A4-3 provides wheel slots to assist in true alignment of aircraft normal to each radial. It may be desirable to construct a special device for use in obtaining true alignment for the calibration pad shown in figure A4-2. One method of establishing control points consists of hollow shell non-magnetic inserts along each radial. A wooden block with aluminum or bronze bolts to fit into the center hole of the brass insert can then be used to provide an accurate alignment of the aircraft wheels. Figure A4-1 shows design details of this system.

e. There are many satisfactory ways of providing a device to wheelblock an aircraft to obtain the required alignment, and the exact method is left to the discretion of the design engineer. The method detailed in Figure A4-1 is one suggestion. One alternative which comes to mind is the possibility of forming holes in the concrete with some form of removable dowel, rather than constructing the specially built brass inserts.

5. <u>LOCATION OF COMPASS CALIBRATION PAD</u>. The requirements specified herein have been determined through consultation with instrument calibration specialists, fixed base operators, and persons in the Geological Survey with considerable experience in performing surveys of compass calibration pads.

a. Locate the site at least 300 feet (90 m) from power and communication cables (both above and below ground) and from other aircraft. Locate the site at least 600 feet (180 m) from large magnetic objects such as buildings, railroad tracks, high voltage electrical transmission lines, or cables carrying direct current (either above or below ground). In order to prevent interference with electronic navigational aid facilities located on the airport, make sure that the required clearances are maintained as specified in chapter 6. Control cables, runway and taxiway light bases or sign fixtures, pipelines, ducts, grates for drainage, distance remaining signs, and aircraft arresting gear should be avoided when they contain ferrous materials.

b. The compass calibration pad must be located off the side of a taxiway or runway a sufficient distance to satisfy the runway and taxiway clearances applicable to the airport on which it is located.

c. After tentative selection of a site through visual application of appropriate criteria contained herein, make a thorough magnetic survey of the site. Many sites which meet all visually applied criteria regarding distances from structures, etc., still are unsatisfactory because of locally generated or natural magnetic anomalies. At locations near heavy industrial areas, intermittent magnetic variations may be experienced and sufficient surveys at various periods of time are necessary to ascertain if this situation exists.

d. The difference between magnetic and true north must be uniform in the vicinity of the site. Make sufficient surveys to determine that the angular difference between true and magnetic north measured at any point does not differ from the angular difference measured at any other point by more than one-half degree within a space between 2 and 10 feet (0.6 and 3 m) above the surface of the base and extending over an area within a 250-foot (75 m) radius from the center.

6. <u>CONSTRUCTION OF COMPASS CALIBRATION PAD</u>. For pavement construction, the applicable portions of AC 150/5320-6 should be used. The following additional information is important:

a. Do not use magnetic materials, such as reinforcing steel or ferrous aggregate, in the construction of the calibration pad or of any pavement within a 300-foot (90 m) radius of the center of the site. If a drainage pipe is required within 300 feet (90 m) of the center of the site, use a nonmetallic or aluminum culvert.

b. Each of the radials is oriented within one minute of the magnetic bearing indicated by its markings.

c. Mark the date of observation and any annual change in direction of magnetic north durably and legibly on the surface of the calibration pad near the magnetic north mark. It would be well to establish a permanent monument at some remote location on the true north radial for future reference.

d. The U.S. Geological Survey of the Department of Interior is available to conduct the necessary surveys to determine the difference between true and magnetic north and the uniformity of this difference. The cost for this service is that necessary to cover the expense to the U.S. Geological Survey. Request for this service should be made to the following: Branch of Global Seismology and Geomagnetism, U.S. Geological Survey, Mail Stop 967, Box 25046, Denver Federal Center, Denver, Colorado 80225, Telephone: Area Code (303) 236-1512. There are also many other competent registered surveyors or engineers who are capable of performing these surveys. It is recommended that a qualified engineer be employed to lay out the work in the field and to design the pavement for the critical aircraft that can reasonably be expected to use the pad.

e. After all construction work on the compass pad is completed, it is advisable to have the pad magnetically resurveyed to guard against the possibility of objectionable magnetic materials being introduced during the construction.

f. Magnetic surveys of existing compass calibration pads should be performed at regular intervals of 5 years or less. Additional surveys should be performed after major construction of utility lines, buildings, or any other structures within 600 feet (180 m) of the center of the pad.

7. <u>VOR CHECKPOINT</u>. At some airports, it may be advantageous to collocate a VOR checkpoint with the compass calibration pad. In such instances, the requirements presented in paragraph 201.3212 of FAA Handbook OA P 8200.1, United States Standard Flight Inspection Manual, should be followed.

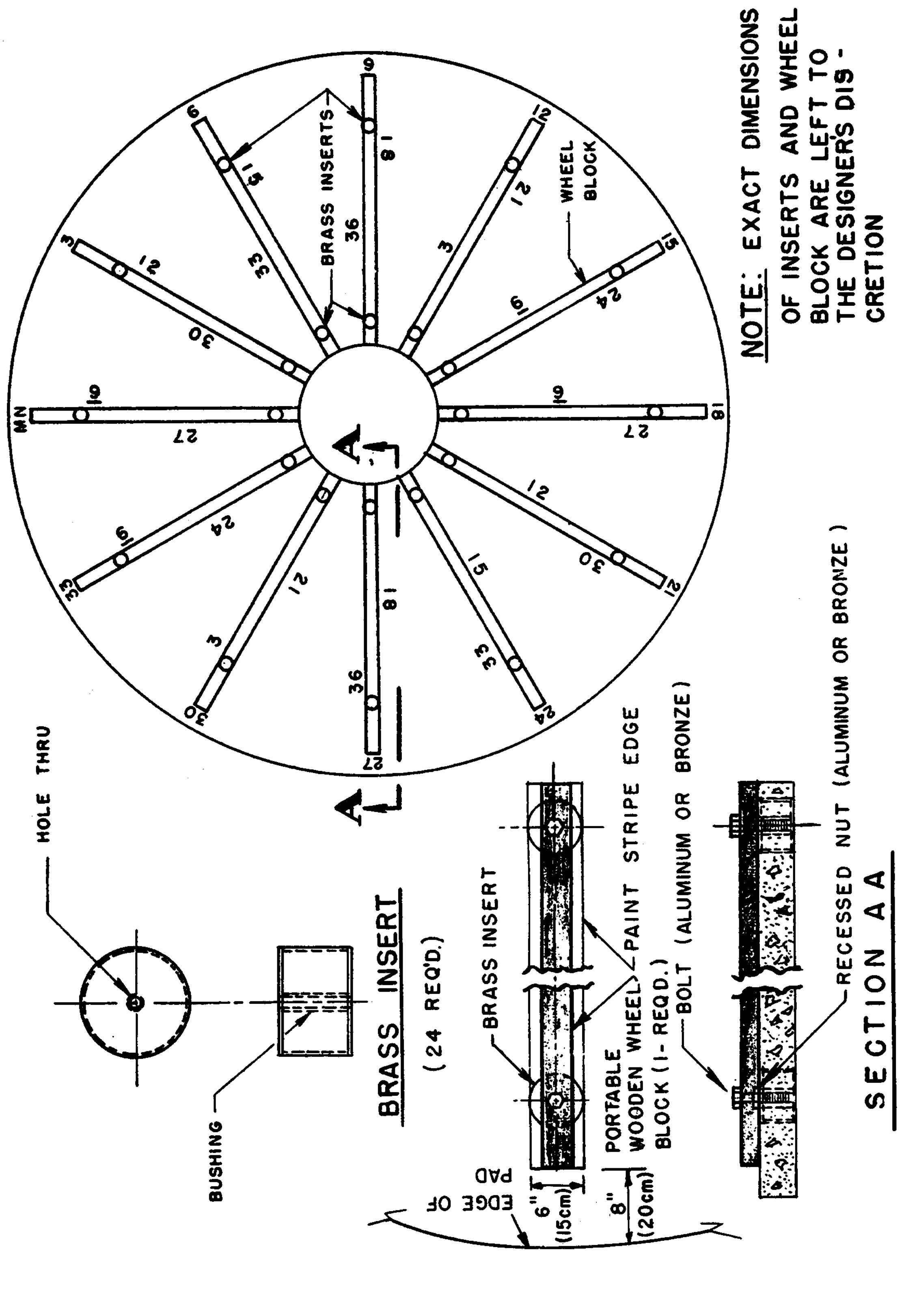


Figure A4-1. Marking layout and details of wheel block

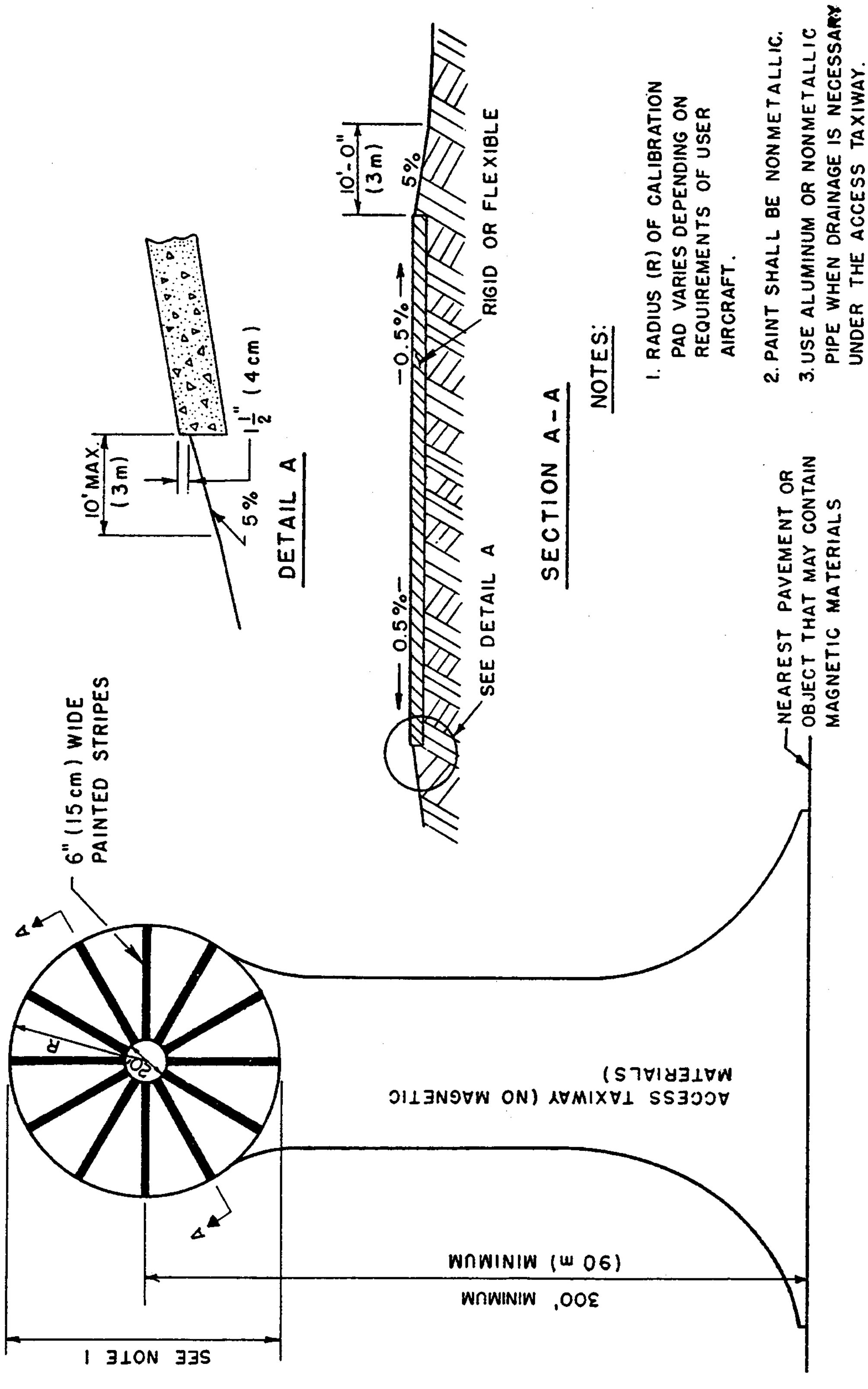


Figure A4-2. Type I. compass calibration pad

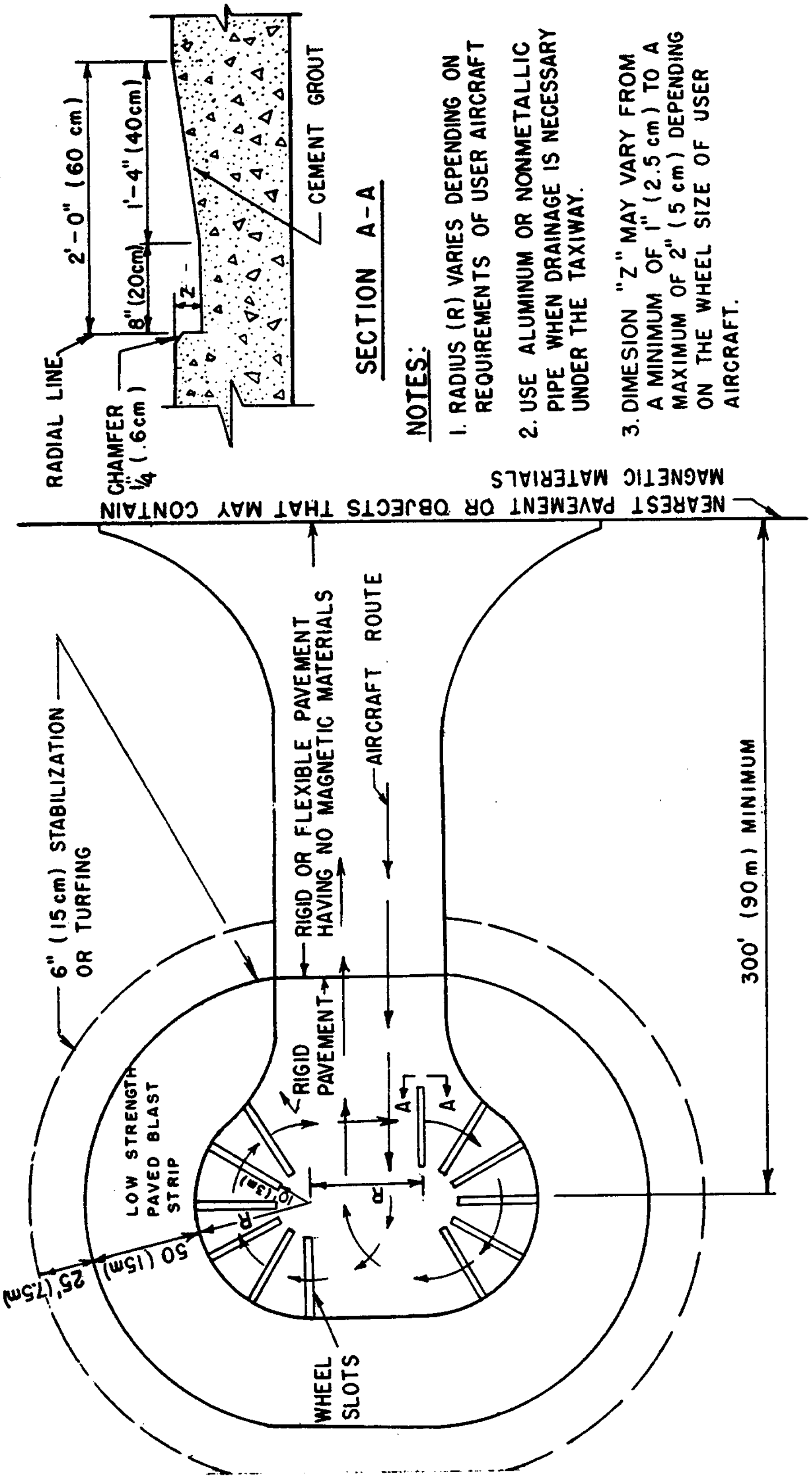


Figure A4-3. Type II. compass calibration pad

Appendix 5. SMALL AIRPORT BUILDINGS, AIRPLANE PARKING, AND TIEDOWNS

1. GENERAL. This chapter provides guidelines on airport buildings, airplane parking, and tiedowns at small airports. Airport buildings fulfill the needs of specific aviation activities. The fixed base operator's (FBO) building usually provides space for the commercial activities, maintenance and repair of aircraft, air charter, and the like. The administration building accommodates the public, pilots, passengers, visitors and also the airport manager's office. Constructed small airplane hangars generally house only airplanes.

a. Figure A5-1 illustrates a typical layout for the building area of a small airport. Siting the FBO building adjacent to the airplane parking apron offers both convenience for local and itinerate pilots. Apron frontage is a premium airport space and should be judiciously utilized. Most hangaring is essentially a garaging operation which usually does not require direct apron front access. The administration building should be near the FBO but sufficiently separated to preclude conflict between airplanes operating from these areas. Storage hangars are often T-hangars, grouped in multiunits in a separate area.

b. Other aviation-oriented buildings may be necessary on the airport. The function(s) of such a building in relation to other aviation activities helps determine its optimum location.

c. An airport master planning study indicates the number of based and transient airplanes expected to utilize the airport. This information will assist in the layout and design of the airplane parking apron(s) and tiedown area(s).

d. AC 150/5360-13 contains guidance on the planning and design of airport terminal buildings and related access facilities at large airports.

2. TRANSIENT APRON. Aprons provide parking for airplanes, access to the terminal facilities, fueling, and surface transportation. A determination on the total amount of apron area needed cannot be developed by formula or empirical relationship since local conditions often vary significantly from one airport to another. The ideal solution is conducting an onsite survey during typical busy days and counting the airplanes on the ground periodically during the day. This approach, however, is impossible for new airports and likely impractical for many airports without a manager. Below is a method which includes factors that affect the determination of the area needed for transient parking and analyzes and estimates the demand for the transient airplane.

a. Calculate the total annual operations (local plus itinerant) from the best available source. Where specific data are not available, the following data, which reflect local plus itinerant operations, may be used: Non-NPIAS Public Use - 538/based aircraft; Reliever - 492/based aircraft; Other General Aviation -637/based aircraft; and Primary - 700/based aircraft.

b. Obtain the record of aviation gas sales for the year for the airport.

c. Correlate gas sales with annual operations on a monthly basis.

d. Calculate the average daily operations for the most active month.

e. Assume the busy day is 10 percent more active than the average day.

f. Assume that a certain portion of the transient airplanes will be on the apron during the busy day. Consider fifty percent as a reasonable figure.

g. Allow an area of 360 square yards per transient airplane.

h. Adjust the calculated amount to accommodate expansion for at least the next 2-year period. A minimum suggested increase is 10 percent.

3. APRON FOR BASED AIRPLANES. The apron used for based airplanes should be separate from the transient airplanes. The area needed for parking based airplanes should be smaller per airplane than for transient. This is due to knowledge of the specific type of based airplanes and closer clearance allowed between airplanes. The following considerations apply in determining the total apron area required for based airplanes:

a. The total number of based airplanes.

b. The number of airplanes now hangared or expected to be within 2 years.

c. The number of airplane owners who will continue to tie down their airplane in a turfed (unpaved) area. At many general aviation airports a certain percentage of airplane owners will prefer to tie down in the most inexpensive area.

d. An area of 300 square yards (250 m^2) per airplane. This should be adequate for all single engine and light twin engine airplanes, such as the Cessna 310, which has a wingspan of 37 feet (11 m) and a length of 27 feet (8 m).

e. An increase in total area to accommodate expansion for at least the next 2-year period. A minimum suggested increase is 10 percent.

4. TIEDOWNS. Tiedown locations for based airplanes will vary with local preference. The purpose of a tiedown layout is to park the maximum number of airplanes while satisfying taxilane object free area width criteria. Figure A5-2 illustrates two tiedown layouts for small airplanes in Airplane Design Group I. General information on tiedown techniques and procedures is contained in AC 20-35.

5. OTHER CONSIDERATIONS.

a. As airport activity increases, the demand for an area to load and unload airplanes will increase. This activity may be in the form of charter, air taxi, business, or personal airplane operations. Generally, the area should be large enough to accommodate two airplanes in front of the terminal building. Also, investigate requirements for possible local air mail service.

b. At small general aviation airports, a gas pump facility is usually the most economical method of airplane fueling. A fueling area should be near the terminal building. Some larger general aviation airports use fuel truck operations. Such an operation eliminates the need for gas pump areas and allows more area for airplane parking. In either case, appropriate static grounding capability must be provided.

c. In summary, the apron design should allow for flexibility and expandability. The design should use empirical relationships only when field data are not available. Arrangement of tiedown installation should allow apron area alterations as needed. Keeping both ends of the apron free of structures will enhance future expansion.

6. HANGARS. Figure A5-3 illustrates typical layouts of hangar areas for different types of hangars. As noted, the recommended clearance between T-hangars is 75 feet (23 m) for one-way traffic and 125 feet (38 m) for two-way traffic. These clearances will accommodate most twin engine general aviation airplanes.

a. Prefabricated T-hangars are available in various sizes and lengths. Details on their erection and cost may be obtained from any of several manufacturers throughout the country.

b. The number of T-hangars depends upon local demand. However, expect a greater demand for protection from weather in the more severe climate areas.

7. ADMINISTRATION BUILDING. The necessity of an administration building is a managerial question answered on the weight of at least the following two factors. First, operationally, the chief factor is whether the airport can take care of present and anticipated airplane activity. Second, economically, the chief factor is the kind of community the airport serves and how well this community can support general aviation activity. Note that lower activity airports may not initially justify the construction of either an FBO or administration building. In many cases, the initial airport building is a small maintenance hangar with an attached office. Prior to the construction of an administrative type of building on a general aviation airport, the following basic questions should receive consideration:

a. Are there a minimum of 10 airplane departures and arrivals, not including touch and go, during the peak hours of a typically busy day during the year?

b. Is there at least one active fixed base operator on the airport?

c. Is airplane fuel available on the airport?

d. Is a hangar with repair facilities in operation on the airport?

e. Is a full-time airport manager on duty during the normal day?

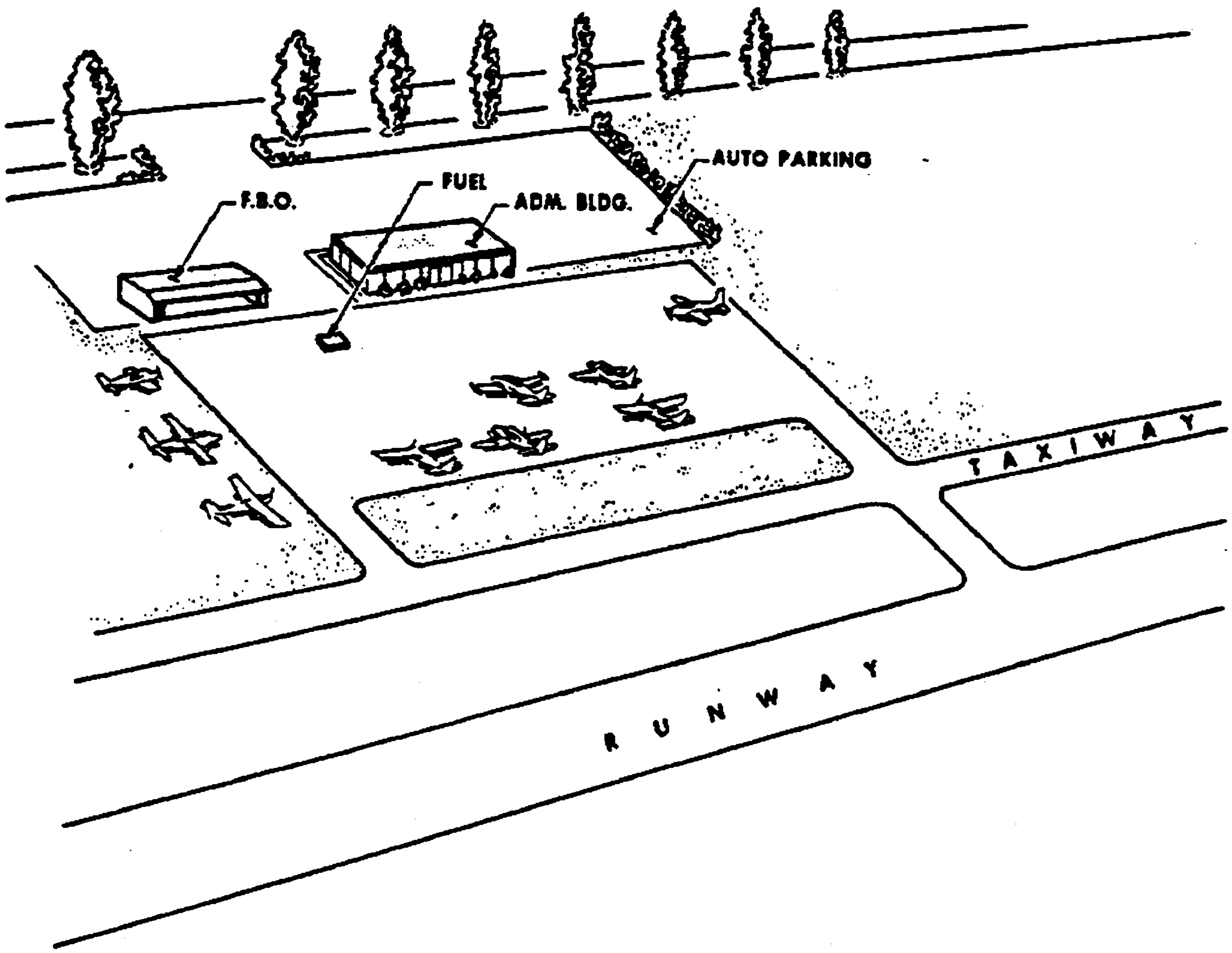


Figure A5-1. Parking apron area

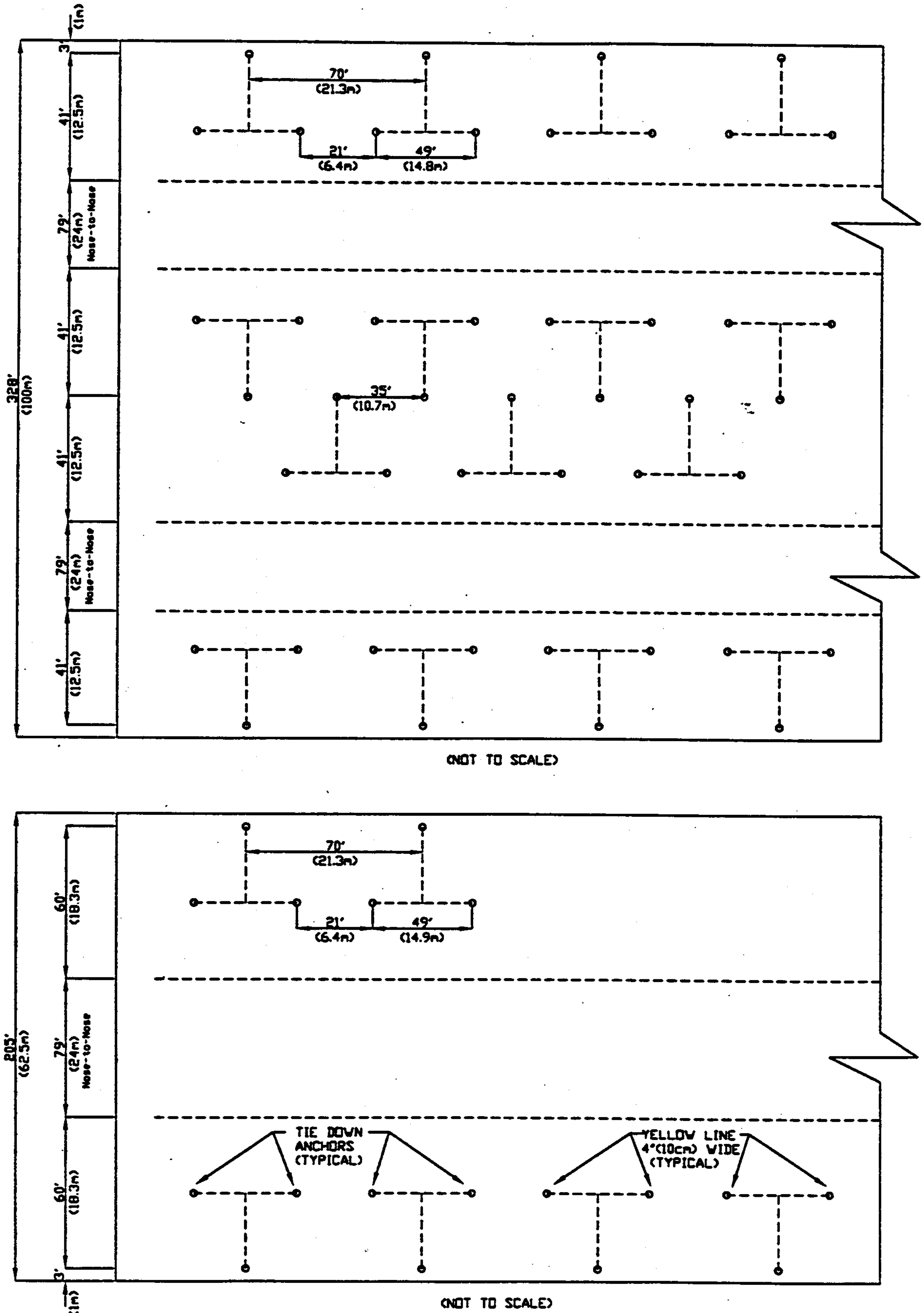


Figure A5-2. Tiedown layouts

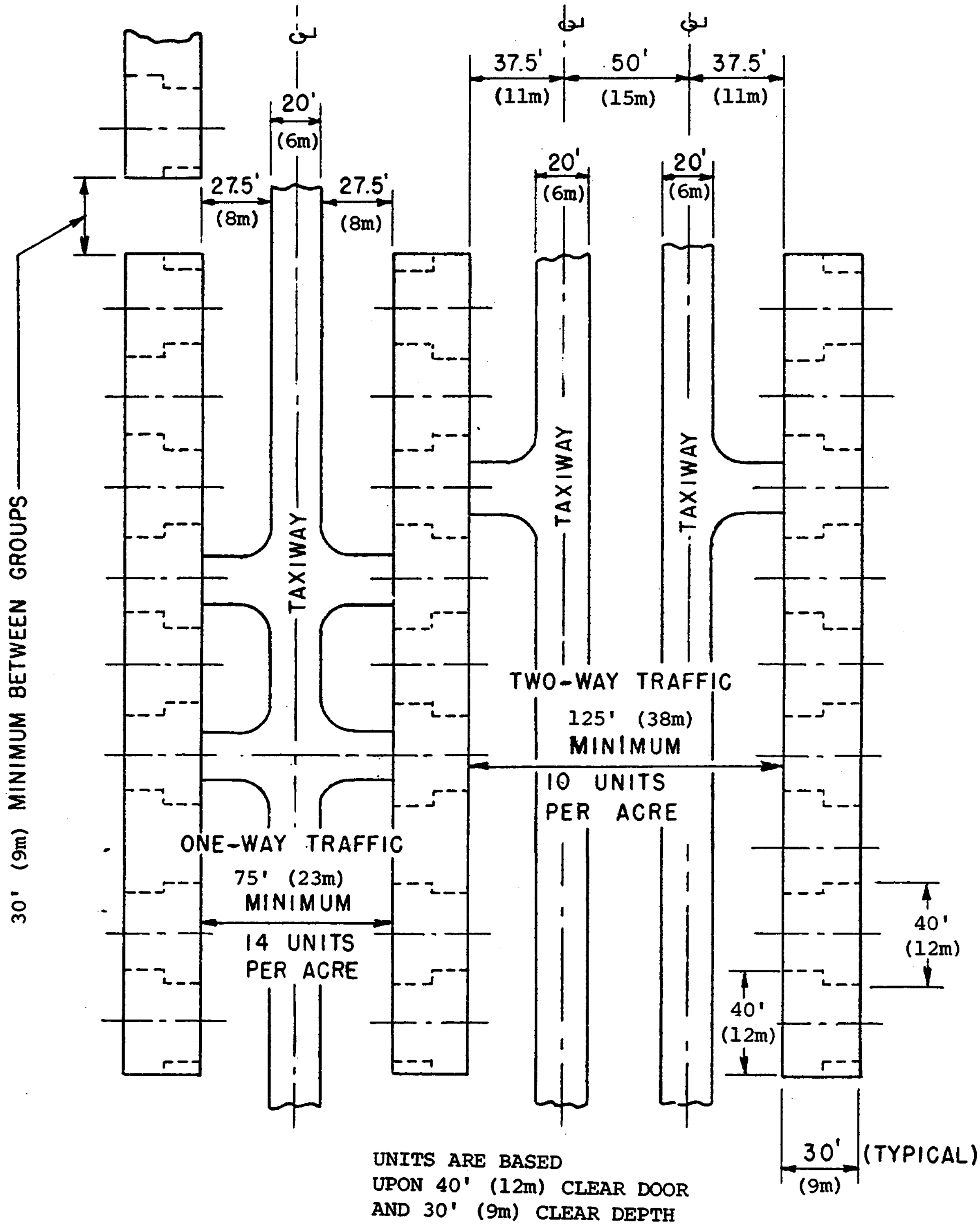


Figure A5-3. T-hanger layout

f. Are public waiting areas and restrooms already available in hangars or other buildings on the airport?

g. Is a public telephone available 24 hours a day for closing flight plans or requesting fuel or transportation to town?

8. AIRPORT SURVEY. A survey of an airport's aviation activity should precede the planning of an administration building. For survey purpose, "airport aviation activity" includes the number of active-based airplanes, the number of airplane operations (local and itinerant), and the number of pilots and passengers at the airport on a typically busy day.

a. A survey of current activity at the airport can determine what functional requirements need accommodating by and the total area of the administration building. Also surveys of other airports with similar aviation activity characteristics which already have administration buildings provide additional valuable data. The airport manager or a fixed base operator can gather the information on several typically busy days over a period of several weeks during the most active season. At many small airports, weekends are usually the busiest days and are a good time to measure peak activity. A Pilots Register is also useful in making a traffic count.

b. With respect to passengers, an airport manager obtains data on the two or three days in the week of the season historically known to be the busiest. This record of the plateau of high activity in terms of peak-hour operations and peak-hour passengers determines the typically busy hour by averaging the hourly activity for three or four of the busiest hours.

9. BUILDING PLAN. The specialized interior requirements of a small administration building are few and should reflect a basic simplicity by providing direct functional relationships between rooms and facilities.

a. The arrangement of elements within the building should address the airfield configuration, future building expansion, and the passenger and service driveways. In determining the details of space relations and requirements, the experienced general aviation airport manager is in the best position to assist in tailoring detailed building needs to actual aviation activity and should be a participant in the early planning conferences.

b. The building components should provide:

(1) Short and direct pedestrian routes from parking areas to public waiting areas or airport offices, and to the loading apron or tiedown areas; and

(2) A view of the airfield operations from the manager's office, the waiting room, and any eating facilities.

10. EXPANSION.

a. Identification of future expansion of the administration building should be from the outset. This is particularly important at a general aviation airport where it is difficult to accurately forecast and assess initial construction cost when based on actual measurable activity.

b. Normally, with the air field side of the building fixed, building expansion occurs only on the off-field side and the ends. When drives and walks resist expansion on the off-field side, all major expansion should proceed on the ends of the building.

11. CIRCULATION. The waiting room is the hub from which circulation routes radiate. Usually, an open plan with only the minimum essential partitioning allows better circulation and a more spacious building interior. The following items are important in assuring a satisfactory circulation of traffic through the building:

a. Short and direct routes from the entrance of the off-field side of the building to the exit on the field side.

b. Wide doorways at the main entry and exits.

c. Public corridors, as necessary, wide enough for comfortable traffic flow, but not excessive to raise initial and maintenance costs.

d. Adequate circulation aisles within the waiting area to assure free movement and comfort for the room occupants.

12. WAITING ROOM. As the central meeting and waiting space for passengers, visitors, pilots, and airport employees, the waiting room is the focal point of the building. It should merge with such other required spaces as the manager's office, eating facilities, and public restrooms. The closer this relationship, the more economical the building. Additional recommendations follow:

a. A view of airfield activities. The public enjoys seeing airplanes and their operations. Do not put utility rooms, restrooms, and other service facilities on the field side of the building if possible.

b. A comfortable seating arrangement. Comfortable seating need not be fixed seats or stereotyped. Such an arrangement at a small airport is especially good to promote the waiting room informality usually associated with small airport operations.

c. Concession items such as coin-operated parcel lockers and small item dispensing machines.

d. A bulletin board for information of interest to private pilots and the aviation public; for example, weather reports, notices to airmen, and FAA information.

e. Space for the mounting of aeronautical charts.

f. A folding partition to provide dual space use. This flexible arrangement conserves building space and makes it possible to hold meetings in the administration building without disturbing the essential business routine.

g. A public phone for closing flight plans, weather briefings, calling public transportation, etc.

13. MANAGER'S OFFICE. Expect variation in the room space for management use at a particular airport. Determining the local management's space requirements should follow after an analysis of the management equipment, furnishings, and personnel space needs. As a general planning guide, the minimum office size sufficient for the furnishings and functions of an office for a manager and one secretary should be about 180 square feet (17 m^2).

14. EATING FACILITIES. Normally, some provision for food services is in the administration building for the comfort and convenience of airport users. The scope of the eating facilities in the building varies with local and itinerant aviation activity. There may be dispenser items, a snack bar, a coffee shop, a dining room, or a combination of these. Frequently, the airport eating facility attracts additional patrons because of its convenient location, its unusual cuisine, or the interest which the patrons have in aviation activity.

a. Food and drink dispensers are usually enough to satisfy initial needs at general aviation airports. Dispenser service requires little attention to operate. Grouped dispensers can better be seen from the main circulation route between the waiting area and the operation/management office.

b. Usually a concessionaire operates the coffee shop or dining room service. It is important to select the concessionaire early enough to receive concessionaire input in planning that part of the administration building. Computing the required size of space should proceed in terms of seated patrons and the kind and amount of food service and preparation equipment. Additional recommended planning considerations are:

(1) Direct relation with the waiting room;

(2) Convenient route from public entrances;

(3) Direct access from the food preparation area to the outside service drive;

(4) View of the airfield activity from the seating area; and

(5) Compliance with public health agency requirements.

15. PUBLIC RESTROOMS. Restrooms should be immediately accessible from the waiting room and meet federal, state, and local requirements for the handicap impaired.

16. ROADS AND AUTO PARKING. Establishing roads and parking areas directly related to the administration building should follow after arranging the configuration of the building, including passenger entrances/exits and service entries. Other important considerations are as follows:

a. Location of short-limit parking or stopping spaces should be close to the main off-field public entrance with enough distance left between building and parking spaces for any future building expansion planned toward these parking spaces.

b. Consolidation of public and employee parking spaces should be into one centrally located parking area when both an administration building and a hangar area are contemplated. This plan is feasible when a convenient relation is established from the outset between the administration building and the hangars.

c. For special events, there should be one or more well-drained turfed areas, located beside the airport access roads for overflow parking.

d. Additional parking areas should exist if the administration building contains eating facilities which outside customers regularly patronized.

e. There should be separate service drives for kitchens from public drives and parking. However, the service drive may often be adjacent to the apron access drive. This requires preventive measures to prohibit restaurant vehicles from inadvertently driving onto the apron.

f. Designated parking spaces for the handicap impaired are required to comply with applicable federal, state, and local requirements

Appendix 6. METRIC CONVERSION AND TYPICAL AIRPORT LAYOUT PLAN

1. GENERAL. The intent of this appendix is to discuss metric conversion and to present concepts that go beyond simple conversion or the mathematical manipulation of values.

a. Policy. Public Law 94-168, Metric Conversion Act of 1975, declares a national policy of coordinating the increasing use of the metric system in the United States. The metric system of measurement is interpreted to mean the SI units as established by the General Conference of Weights and Measures in 1960. The transition to the metric system is to be voluntary and evolutionary with industry setting the pace. This means that the airport authority has the option to design the airport in either the U.S. customary or SI units. In keeping with the spirit of this policy, it is the intent of this chapter to provide metric transition guidance to those architects, engineers, and planners whose responsibility is to develop airport layout plans.

b. State of the Art.

(1) At the present time, much of the conversion practice as seen in trade literature is limited to a dual system with equivalent units being expressed in parentheses. Firms in foreign practice have developed an expertise in working in the metric system.

(2) Numerous conversion tables are available for simple conversion of values; however, in order to carry the transition to its logical conclusion, we should become acquainted with such subjects as SI style, usage, accuracy, and rounding techniques. For a more comprehensive discussion of the SI system, American Society for Testing and Materials, ASTM E 380 Standard for Metric Practice, and the Metric Manual, U.S. Department of the Interior, Bureau of Reclamation, are recommended references for engineers.

(3) Development of airport layout plans and other drawings can be in three ways:

(a) SI units only.

(b) U.S. customary units only.

(c) A combination of both systems.

The development of two sets of drawings fulfills various requirements of bidding and construction. This practice is a duplication of effort, but it may be economically justified under some circumstances when it is necessary to work in a medium in which people are familiar. Dual units can be on the same drawing; however, this practice leads to clutter, confusion, and errors by using customary units for SI units and vice versa.

c. The Hard Conversion Concept. Hard conversion is a new dimension judged to be a preferred or rationalized SI value. This new dimension is a change in the item's properties and will eventually result in international standardization of products and dimensions. Hard conversion has met with resistance to change because of presumed economical impact associated with change in dimension and modification of equipment. The FAA recommends the use of the hard conversion concept to the maximum extent practicable.

d. The Exact Conversion Concept. Exact conversion as the name implies relates to a type of conversion that results in a high degree of precision that may usually be associated with legal, scientific, or statistical applications rather than in the development of an airport layout plan. Airport design requires exact conversion at all interfaces between items designed under different systems of units.

e. The Soft Conversion Concept. Soft conversion results in essentially rounding of the converted value to the nearest integer or sensible number. The item or construction remains unaltered because the conversion is really nothing more than an interim form of conversion, rather than the creation of a dimensionally new component. This type of conversion may be used when the metric standard is not available.

f. Rounding of Converted Value. The recommended approach to rationalized dimensions is the following:

DIMENSIONAL CLASSIFICATION

Order of pref.	Very small dimensions up to about 50 mm	Small dimensions up to about 300 mm	Medium dimensions up to about 6000 mm	Large dimensions site layouts roadworks	Other numerical values	
					Range 1 to 100	Range 100 to 1000
1st	10 mm	100 mm	600 mm	10 m	10	100
2nd	5 mm	50 mm	300 mm	5 m	5	50
3rd	2 mm	25 mm	100 mm	1 m	2	20
4th	1 mm	10 mm	50 mm	.5 m	1	10
5th		5 mm	25 mm	.1 m		
6th		2 mm	10 mm			
7th		1 mm				

These values should be applied to achieve a reasonable balance between the smallest percent error and the highest order of preference.

2. TYPICAL AIRPORT LAYOUT PLAN.

a. Introduction. The typical airport layout plan, figure A6-1, depicting a small airport.

b. Drawing Scales. Selection is basically a matter of choice; however, one should choose a scale that is easy to work with and that will enable appropriate details to be shown conveniently. The following list is a suggested reference:

Type of map	U.S. customary system		Metric system	
	(Inches) (Feet)	Unit ratio	(cm) (m)	Unit ratio
Location	1 - 2,000	1:24,000	1 - 250	1:25,000
Vicinity	1 - 4,000	1:48,000	1 - 500	1:50,000
Airport layout plan	1 - 200 to 1 - 600	1:2,400 to 1:7,200	1 - 25 to 1 - 500	1:2,500 to 1:5,000

c. Contours.

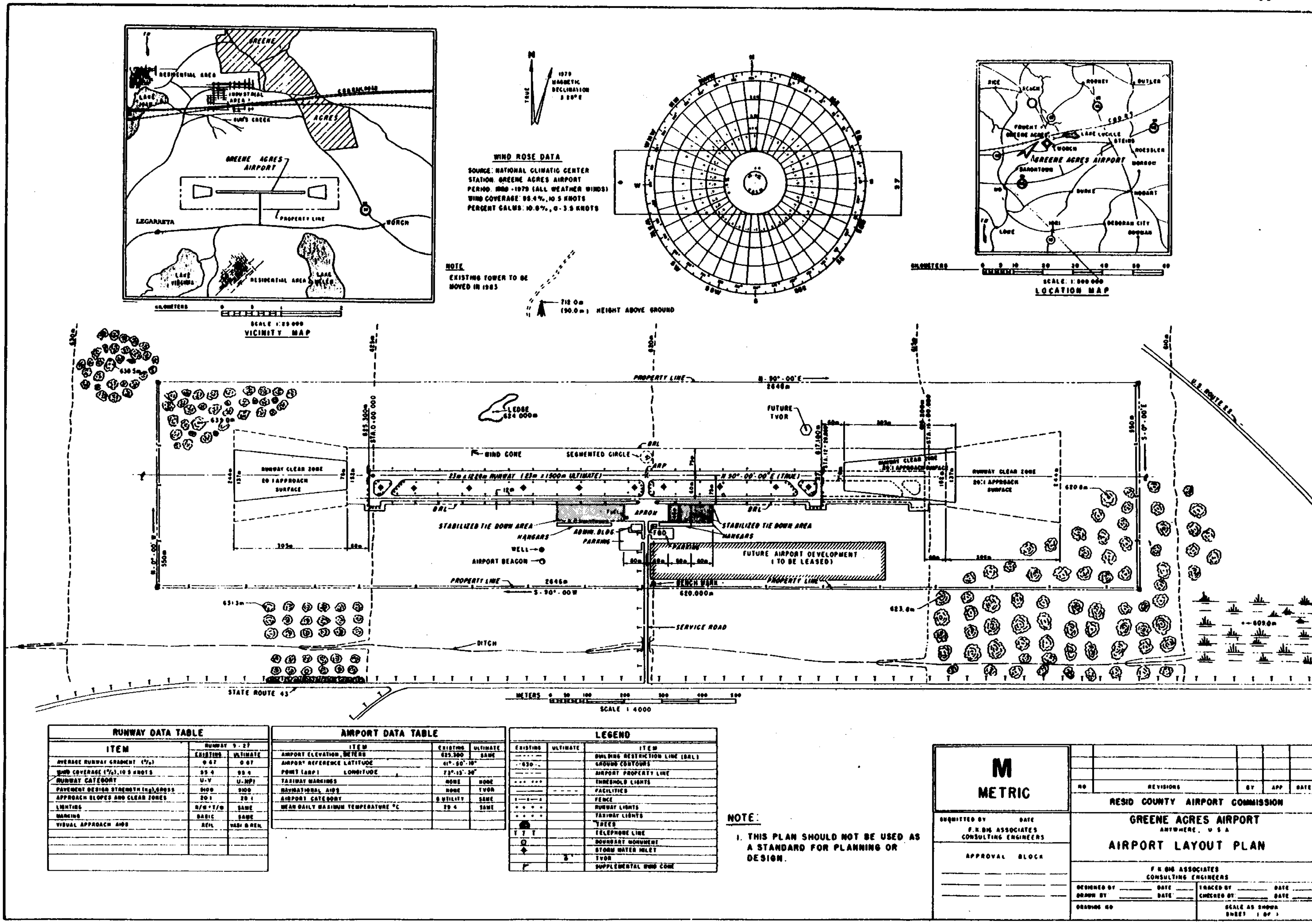
(1) One requirement of the airport layout plan is to indicate surface grades by contours so that drainage can be assured and obstructions identified. Contour intervals should be chosen such that they adequately show the important features and changes in ground elevation. On relatively level terrain, the contour interval should be 1 foot. The contour lines, however, should not be so numerous or pronounced that they clutter the drawing or overpower the other details.

(2) A topographic survey is one method of determining the existing elevations and physical features of an area to be developed. This survey can be run independently or in conjunction with a property line survey. Because of the transitional climate that exists at this time and because of the compatibility with available equipment and existing land records, land surveyors are still practicing in customary units. This does not mean that data taken in the customary system cannot be transformed and presented in metric units if required or requested.

(3) U.S. Geological Survey topographic maps show existing contours. All new U.S. Geological Survey topographic maps are being developed in the metric system, except in those states that have not been completed and have optioned for completing the balance of their contracts in the customary system. Puerto Rico is mapped in the 1:20,000 metric scale, 7.5 X 15 minute format. In those localities where a metric topographical map exists, there will be no

problem developing metric contours; but in those areas where a metric map does not exist, some form of conversion will be necessary to work from available 1:24,000-scale topographical maps.

(4) It is recommended that elevations be shown in meters, with the number of decimal places used to be a function of the precision required. For example, elevations for earthwork and excavations will be shown to two decimal places, while concrete and steel work will be shown to three places.



RUNWAY DATA TABLE

ITEM	RUNWAY 9-27 EXISTING	RUNWAY 9-27 ULTIMATE
AVERAGE RUNWAY GRADIENT (%)	0.67	0.67
WIND COVERAGE (%), 10.5 KNOTS	95.4	95.4
RUNWAY CATEGORY	U-V	U-NPI
PAVEMENT DESIGN STRENGTH (kg), GROSS	5400	5400
APPROACH SLOPES AND CLEAR ZONES	20:1	20:1
LIGHTING	R/W+T/W	SAME
MARKING	BASIC	SAME
VISUAL APPROACH AIDS	REIL	VASI & REIL

AIRPORT DATA TABLE

ITEM	EXISTING	ULTIMATE
AIRPORT ELEVATION, METERS	625.300	SAME
AIRPORT REFERENCE POINT (ARP) LATITUDE	41°-50'-10"	
LONGITUDE	73°-15'-30"	
TAXIWAY MARKINGS	NONE	NONE
NAVIGATIONAL AIDS	NONE	TVOR
AIRPORT CATEGORY	B UTILITY	SAME
MEAN DAILY MAXIMUM TEMPERATURE °C	29.4	SAME

LEGEND

EXISTING	ULTIMATE	ITEM
		BUILDING RESTRICTION LINE (BRL)
630		GROUND CONTOURS
		AIRPORT PROPERTY LINE
		THRESHOLD LIGHTS
		FACILITIES
		FENCE
		RUNWAY LIGHTS
		TAXIWAY LIGHTS
		TREES
		TELEPHONE LINE
		BOUNDARY MONUMENT
		STORM WATER INLET
		TVOR
		SUPPLEMENTAL WIND CONE

Figure A6-1. Typical airport layout plan

Appendix 7. AIRPORT LAYOUT PLAN COMPONENTS AND PREPARATION

AIRPORT LAYOUT PLAN COMPONENTS

1. Narrative Report
2. Airport Layout Drawing
3. Airport Airspace Drawing
4. Inner Portion of the Approach Surface Drawing
5. Terminal Area Drawing
6. Land Use Drawing
7. Airport Property Map

AIRPORT LAYOUT PLAN (ALP) PREPARATION

1. NARRATIVE REPORT.

a. Definition - A condensed report explaining the reasoning behind, and important features of the ALP. The narrative report, in preliminary format, should accompany the first submission of a preliminary ALP for agency and sponsor review. (When Airport Layout Plan preparation is being accomplished in conjunction with a Master Plan Study, the Master Plan Report will contain this information so that a separate ALP Narrative Report is normally not needed.)

b. Includes:

(1) Basic aeronautical forecasts.

(2) Basis for proposed items of development.

(3) Rationale for unusual design features and/or modification to FAA Airport Design Standards.

(4) Development summary for stages of construction and layout sketches depicting the main items of development in that stage.

c. Preparation Guidelines:

(1) Forecasts - Extent depends on airport size and use. As a minimum, include 0-5, 6-10, 11-20 year forecasts for:

(a) Total annual operations.

(b) Annual itinerant operations (all aircraft).

(c) Based aircraft.

(d) Annual instrument approaches.

(e) Annual itinerant operations by current **design aircraft**.

(f) Annual itinerant operations by future more demanding airplane.

(2) Stage Development - Summarize major developments for three stages (0-5, 6-10, and 11-20 year), and depict these stages on sketches.

(3) Coordination - Obtain and append to the Report evidence that the ALP was coordinated with appropriate local and state governmental units (e.g., City or Metropolitan Planning Agency, County Board of Supervisors, State Highway Department, Utility Companies, etc.), and found to be consistent with their plans.

(4) Other - Remember the primary purpose of the narrative report is to provide useful and understandable information and guidance to the airport sponsor. It also provides the FAA with important information needed to review and ultimately approve the ALP.

2. AIRPORT LAYOUT DRAWING.

a. Features:

(1) Layout of existing and proposed facilities and features.

(2) Wind rose and coverage analysis.

(3) Basic airport and runway data tables.

(4) Legend and building tables.

(5) Title and revision blocks.

(6) Sponsor approval block.

(7) List of approved modifications to FAA Airport Design Standards, including proposed and planned modifications to standards, such as the use of declared distances for airport design, expected to be approved as part of the ALP review and approval process.

b. Preparation Guidelines:

(1) Sheet size - 22" x 34".

(2) Scale - Determined by airport size. Stay within range of 1" = 200' to 1" = 600' (1:2 000 to 1:8 000).

(3) North Point - Indicate both True and Magnetic North and the year of the magnetic declination used. Orient drawing so that north is to the top of sheet. If this is not practicable, orient north so that it is to the left.

(4) Wind Rose

(a) Cite data source (i.e., weather station) and time period covered.

(b) Include individual and combined coverage for:

1) Runways with 10.5 knots crosswind.

2) Runways with 13 knots crosswind.

3) Runways with 16 knots crosswind.

4) Runways with 20 knots crosswind.

(5) Airport Reference Point (ARP) - Show location based on ultimate airport configuration with latitude and longitude to the nearest second based on NAD 83.

(6) Topographic Information - Show ground contours at intervals of 2 feet to 10 feet (1 m to 5 m) depending on terrain. Draw in with very light lines.

(7) Elevations: Include the following:

(a) Runway - at existing and ultimate ends, displaced thresholds, touchdown zones, intersections, high and low points - accuracy to the nearest 1/10 of a foot (1 cm) where the elevation is not subject to change with time.

(b) Structures on Airport - If Terminal Area Plan Drawing is not to be included, show top elevations on this sheet. Use table and numbering system.

(8) Building Restriction Lines - Show on both sides of runways and extend to airport property line or RPZ. Also, use to restrict buildings from "runway visibility zones."

(9) Runway Details - Include the following:

(a) Approach Visibility Minimums - Include designated or planned approach visibility minimums (V, 1 MILE, 3/4 MILE, 1/2 MILE, CAT II, or CAT III) in the Runway Data Table.

(b) Dimensions - Note length and width (for existing and ultimate) within outline of runway. Include the runway length in the Runway Data Table.

(c) Pavement Design Strength - Include pavement design strength in the Runway Data Table.

(d) Orientation - Depict runway end numbers and show true bearing - accuracy to nearest 0.01 degree.

(e) Lighting - Depict existing and ultimate threshold lights with symbols. Show type of lighting (MIRL, etc.) in Runway Data Table. Don't depict runway edge lights on drawing.

(f) Marking - Include the type of runway markings (V, NP, or P) in the Runway Data Table.

(g) Stage Lengths - Show only existing and ultimate. (Depict interim stage lengths on stage development sketches in ALP Narrative Report.)

(h) End Coordinates - Note end (existing and ultimate) of each runway - accuracy to nearest 0.01 second.

(i) Monuments - Depict the location of all survey monuments and reference markers. As a minimum, monuments should be established to locate the runway centerline at the runway ends and at displaced thresholds. Include a note describing the manner in which these monuments are protected.

(j) Declared Distances - Identify any clearway/stopway portions in the declared distances and any runway portions not included in the declared distances. Include all declared distances for all runway directions in the Runway Data Table. Declared distances associated with each runway direction may also be shown on the drawing (refer to appendix 14).

(10) Object Free Areas (OFA) - Include the existing and ultimate OFA dimensions in the Runway Data Table as OFA width and length of OFA beyond the stop end of runway and/or depict the OFA on drawing with dimensions.

(11) Safety Areas (RSA) - Include the existing and ultimate RSA dimensions in the Runway Data Table as RSA width and RSA length beyond the stop end of runway and/or depict the RSA on drawing with dimensions.

(12) OFZ Details - Specify "NO OFZ OBJECT PENETRATIONS" when no object other than frangible NAVAIDS penetrates the OFZ. Otherwise show the object penetrations and indicate how they will be eliminated. The OFZ may be depicted on the drawing with dimensions to facilitate identifying object penetrations. Refer to paragraph 306 for the location, configuration, and dimensions of the OFZ.

(13) Threshold Details - Depict the thresholds with coordinates - accuracy to nearest 0.01 second, elevation, displacement from runway end, and print "NO THRESHOLD SITING SURFACE OBJECT PENETRATIONS" when no object penetrates the threshold siting surface. Otherwise show the object penetrations and indicate how they will be eliminated. The threshold siting surface may be depicted on the drawing with dimensions to facilitate identifying object penetrations. Refer to appendix 2, paragraph 5 for the location, configuration, and dimensions of the threshold siting surface.

(14) RPZ Details

(a) Size - Dependent on operational use (refer to chapter 2). Indicate existing and ultimate sizes on drawing either with note or dimensions.

(b) Property acquisition - Indicate type (fee or easement) with appropriate legend symbol. NOTE: Boundary of existing property interest may, or may not, coincide with current RPZ boundary.

(c) Residences and Places of Public Assembly - Show residences and places of public assembly and how they will be removed on the drawing.

(15) Holding Position Signs and Markings - Depict the holding position signs and markings distance from runway centerline. Use dimension lines.

(16) Taxiway Details - Include the following:

(a) Dimensions - Show widths and separations from runway centerline, parallel taxiway, aircraft parking, and objects. Use dimension lines.

(b) Lighting and marking - Indicate by notes in Airport Data Table (refer to figure A6-1).

(17) Airport Data Table - As per example in figure A6-1.

(18) Runway Data Table - As per example in figure A6-1.

(19) Legend Table - As per example in figure A6-1.

(20) Building Table - Identify existing and proposed structures by number and include a description of the structure. When appropriate, expand to include a column for the top building elevations if a Terminal Area Drawing is not included.

(21) Location and Vicinity Maps - These are optional.

(22) Title and Revision Blocks - Refer to example in figure A6-1.

(23) Approval Block - Include one for only the airport sponsor. (Submission of final ALPs for FAA approval must reflect sponsor approval of the Plan).

3. AIRPORT AIRSPACE DRAWING.

a. Includes:

(1) Plan view of all 14 CFR Part 77 Subpart C surfaces based on ultimate runway lengths.

(2) Small scale profile views of ultimate Part 77 Subpart C approaches.

(3) Obstruction Data Tables, as appropriate (refer to inner portion of the approach surface discussion).

b. Preparation Guidelines:

(1) Sheet size - same as Airport Layout drawing.

(2) Scale - 1" = 2000' (1:20 000) recommended for the plan view. 1" = 1000' (1:10 000) (horizontal) and 1" = 100' (1:1 000) (vertical) for approach profiles.

(3) Title and Revision Blocks - As per example in Chapter 9 of AC 150/5070-6.

(4) Plan View Details

(a) Use current USGS 7 1/2 minute Quad. for base map when available.

(b) Show runway end numbers.

(c) Include 50-foot (20 m) elevation contours on all sloping surfaces.

(d) When horizontal and/or conical surfaces overlap the approach surface, draw in the more demanding surfaces with solid lines and the others with dashed lines.

(e) Identify objects, and note top elevations thereof, which penetrate any of the surfaces, except those which are within the inner portion of the approach surfaces. For the latter, add note, "Refer to the inner portion of the approach surface plan view details for close-in obstructions."

(f) For precision instrument runways (i.e., approaches 50,000 feet (15 000 m) in length), use a cut line and show the balance of 40,000 feet (12 000 m) approach on a separate sheet.

(g) Include a note specifying any height restriction zoning ordinances/statutes in the airport environs.

(h) Other - Refer to example drawing in Chapter 9 of AC 150/5070-6.

(5) Approach Profile Details

(a) Depict the ground profile along the extended runway centerline representing the composite profile based on the highest terrain across the width and along the length of the approach surface.

(b) Depict all significant objects within the approach surfaces regardless of whether they are obstructions (e.g., roadways, rivers, bluffs, towers, etc.). Note top elevation of all significant objects.

(c) Show existing and ultimate runway ends and Part 77 Subpart C approach slopes.

4. INNER PORTION OF THE APPROACH SURFACE DRAWING.

a. Includes:

(1) For each runway end, a large scale plan view of the inner portion of the approach, usually limited to the area out to where the Part 77 Subpart C approach surface reaches a 100-foot (30 m) height above the runway end.

(2) Projected profile views of Item 1 above.

(3) Obstruction Tables.

b. Preparation Guidelines:

(1) Sheet size - same as other.

(2) Scale - Horizontal 1" = 200' (1:2 000) Vertical 1" = 20' (1:200).

(3) Title and Revision Blocks - Same as for Airport Layout Drawing.

(4) Plan View Details

(a) Use aerial photos for base maps when available.

(b) Use numbering system to identify obstructions.

(c) Depict property line when it is located within the area.

(d) When traverse ways (roads, railroads, waterways, etc.) cross the area beneath the approach surface, show the traverse way elevation and vertical clearance between the traverse way and the approach surface at the approach surface edges and extended runway centerline. Also, number these points for subsequent use on the profile drawings.

(e) Depict existing and ultimate end of runway. Note runway end number.

(f) Show ground contours (with light line) within the area.

(5) Profile View Details

(a) Depict terrain along runway safety area and significant items such as fences, stream beds, roadways, etc., regardless of whether the items are obstructions.

(b) Identify obstructions with numbers used on plan view.

(c) Depict cross-section of roads and railroads with dashed lines where they intersect outer edges of approach surface.

(6) Obstruction Table Details

(a) Prepare separate table for each approach surface and specify type and slope of the Part 77 approach surface.

(b) Provide columns for obstruction identification number and description, the amount of approach surface penetration, and the proposed disposition of the obstructions, including no action.

5. TERMINAL AREA DRAWING.

(The need for this drawing will be decided on a case-by-case basis. For small airports, where the Airport Layout Drawing is prepared to a fairly large scale, a separate drawing for the terminal area may not be needed.)

a. Includes: Large scale plan view of the area (or areas) where aprons, buildings, hangars, parking lots, etc., are located.

b. Preparation Guidelines:

(1) Sheet Size - Same as Airport Layout Drawing.

(2) Scale - Range of 1" = 50' to 1" = 100' (1:500 to 1:1 000 m).

(3) Title and Revision Block - Same as Airport Layout

(4) Building Data Table - For listing structures and showing pertinent information relative to them. Include space and columns for:

(a) Structure identification number (identify structures on plan view with numbers instead of words).

(b) Top elevation of structures.

(c) Obstruction marking (existing and planned).

(5) Legend - Include symbol for indicating planned removal, abandonment, etc.

6. LAND USE DRAWING.

a. Definition - A drawing depicting existing and recommended use of all land within the ultimate airport property line (on airport) and in the vicinity of the airport (off airport to at least 65 LDN). The land uses should be depicted by general use categories (e.g., agriculture, recreational, industrial, aviation, commercial, etc.).

b. Purpose - This drawing provides the airport management a plan for leasing revenue producing areas on the airport. It also provides guidance for determining allowable proximity of farming operations to runways and taxiways. Factors which need to be considered in the preparation of this plan include line of sight between runway ends and within the "runway visibility zones." Furthermore, the drawing provides guidance to local authorities for establishing appropriate zoning in the vicinity of the airport.

c. Preparation Guidelines:

(1) Sheet Size - Same as Airport Layout Drawing.

(2) Scale - Same as Airport Layout Drawing.

(3) Title and Revision Block - Same as Airport Layout Drawing.

(4) Base Map - Use aerial photos when available.

(5) Legend - Within the various parcels and/or areas on and off the airport, use standard drafting symbols (i.e., shading, cross hatching or other tonal effects) to identify recommended land uses by general category (e.g., agricultural, recreational, industrial, commercial, residential, aeronautical, etc.). Use notes to identify existing land uses by general category.

(6) Public Facilities - Depict the location of all public facilities (e.g., schools, hospitals, prisons, parks, etc.) in the vicinity of the airport.

(7) Drawing Details - Normally limited to existing and future airport features (i.e., runways, taxiways, aprons, runway protection zones, terminal buildings and NAVAIDs). The drawing should be sufficiently detailed to allow the airport management to determine limit lines for areas which must be kept in grass or restricted to low growing crops.

7. AIRPORT PROPERTY MAP.

a. Definition - A drawing indicating how various tracts of land within the airport boundaries were acquired (e.g., Federal funds, surplus property, local funds only, etc.). Easement interests in areas outside the fee property line should also be included.

b. Purpose - The primary purpose of this drawing is to provide information for analyzing the current and future aeronautical use of land acquired with Federal funds.

c. Preparation Guidelines:

(1) Sheet Size - Same as Airport Layout Drawing.

(2) Scale - Same as Airport Layout Drawing.

(3) Title and Revision Block - Same as Airport Layout Drawing.

(4) Legend - Use standard drafting symbols (i.e., shading, cross hatching, or other tonal effects) and legend table to indicate the type of acquisition involved with each tract or area.

(5) Data Table - A data table with a numbering or lettering system should be used to show pertinent data applicable to property acquisitions. As a minimum, the following data should be included:

(a) The date the property was acquired.

(b) The Federal aid project number under which the property was acquired. Like property interests acquired with Federal funds under the same project may be grouped together and shown as one tract or area.

(6) Drawing Details - Normally limited to existing and future airport features (i.e., runways, taxiways, aprons, runway protection zones, terminal buildings and NAVAIDs) which would indicate aeronautical need for airport property.

(a) Details should be subordinated to property lines and tract outlines by half toning, screening, or other similar techniques.

(b) A screened reproducible of the Airport Layout Drawing may be used as the base for the Airport Property Map.

(c) Airport boundary lines and lines depicting property interest areas should be bold so as to stand out from background details.

Appendix 8. RUNWAY DESIGN RATIONALE

1. SEPARATIONS. Dimensions shown in tables 2-1, 2-2, 3-1, 3-2, and 3-3 may vary slightly due to rounding off.

a. Runway to holdline separation is derived from landing and takeoff flight path profiles and the physical characteristics of airplanes. The runway to holdline standard satisfies the requirement that no part of an airplane (nose, wingtip, tail, etc.) holding at a holdline penetrates the obstacle free zone (OFZ). Additionally, the holdline standard keeps the nose of the airplane outside the runway safety area (RSA) when holding prior to entering the runway. When the airplane exiting the runway is beyond the standard holdline, the tail of the airplane is also clear of the RSA. Additional holdlines may be required to prevent airplane, from interfering with the ILS localizer and glide slope operations.

b. Runway to parallel taxiway/taxilane separation is determined by the landing and takeoff flight path profiles and physical characteristics of airplanes. The runway to parallel taxiway/taxilane standard precludes any part of an airplane (tail, wingtip, nose, etc.) on a parallel taxiway/taxilane centerline from being within the runway safety area or penetrating the OFZ.

c. Runway to airplane parking areas is determined by the landing and takeoff flight path profiles and physical characteristics of airplanes. The runway to parking area standard precludes any part of a parked airplane (tail, wingtip, nose, etc.) from being within the runway object free area or penetrating the OFZ.

2. OBSTACLE FREE ZONE (OFZ). The portion of the OFZ within 200 feet (60 m) of the runway centerline is required for departure clearance. The additional OFZ, beyond 200 feet (60 m) from runway centerline, is required to provide an acceptable accumulative target level of safety without having to adjust minimums. The level of safety for precision instrument operations is determined by the collision risk model. The collision risk model is a computer program developed from observed approaches and missed approaches. It provides the probability of an airplane passing through any given area along the flight path of the airplane. To obtain an acceptable accumulative target level of safety with objects in the OFZ, operating minimums may have to be adjusted.

3. RUNWAY SAFETY AREA. In the early years of aviation, all airplanes operated from relatively unimproved airfields. As aviation developed, the alignment of takeoff and landing paths centered on a well defined area known as a landing strip. Thereafter, the requirements of more advanced airplanes necessitated improving or paving the center portion of the landing strip. The term "landing strip" was retained to describe the graded area surrounding and upon which the runway or improved surface was constructed. The primary role of the landing strip changed to that of a safety area surrounding the runway. This area had to be capable, under normal (dry) conditions, of supporting airplanes without causing structural damage to the airplanes or injury to their occupants. Later, the designation of the area was changed to "runway safety area," to reflect its functional role. The runway safety area enhances the safety of airplanes which undershoot, overrun, or veer off the runway, and it provides greater accessibility for firefighting and rescue equipment during such incidents. Figure A8-1 depicts the approximate percentage of airplanes undershooting and overrunning the runway which stay within a specified distance from the runway end. The runway safety area is depicted in figure 3-1 and its dimensions are given in tables 3-1, 3-2, and 3-3.

4. RUNWAY OBJECT FREE AREA (ROFA). The ROFA is a result of an agreement that a minimum 400-foot (120 m) separation from runway centerline is required for equipment shelters, other than localizer equipment shelters. The aircraft parking limit line no longer exists as a separate design standard. Instead, the separations required for parked aircraft and the building restriction line from the runway centerline are determined by object clearing criteria.

5. RUNWAY SHOULDERS AND BLAST PADS. Chapter 8 contains the design considerations for runway shoulders and blast pads.

6. CLEARWAY. The use of a clearway for takeoff computations requires compliance with the clearway definition of FAR Part 1.

7. STOPWAY. The use of a stopway for takeoff computations requires compliance with the stopway definition of FAR Part 1.

8. <u>RUNWAY PROTECTION ZONE (RPZ)</u>. Approach protection zones were originally established to define land areas underneath aircraft approach paths in which control by the airport operator was highly desirable to prevent the creation of airport hazards. Subsequently, a 1952 report by the President's Airport Commission (chaired by James Doolittle), entitled "The Airport and Its Neighbors," recommended the establishment of clear areas beyond runway ends. Provision of these clear areas was not only to preclude obstructions potentially hazardous to aircraft, but also to control building construction as a protection from nuisance and hazard to people on the ground. The Department of Commerce concurred with the recommendation on the basis that this area was "primarily for the purpose of safety and convenience to people on the ground." The FAA adopted "Clear Zones" with dimensional standards to implement the Doolittle Commission's recommendation. Guidelines were developed recommending that clear zones be kept free of structures and any development which would create a place of public assembly.

In conjunction with the introduction of the RPZ as a replacement term for clear zone, the RPZ was divided into "object free" and "controlled activity" areas. The RPZ function is to enhance the protection of people and property on the ground. Where practical, airport owners should own the property under the runway approach and departure areas to at least the limits of the RPZ. It is desirable to clear the entire RPZ of all aboveground objects. Where this is impractical, airport owners, as a minimum, shall maintain the RPZ clear of all facilities supporting incompatible activities. Incompatible activities include, but are not limited to, those which lead to an assembly of people.

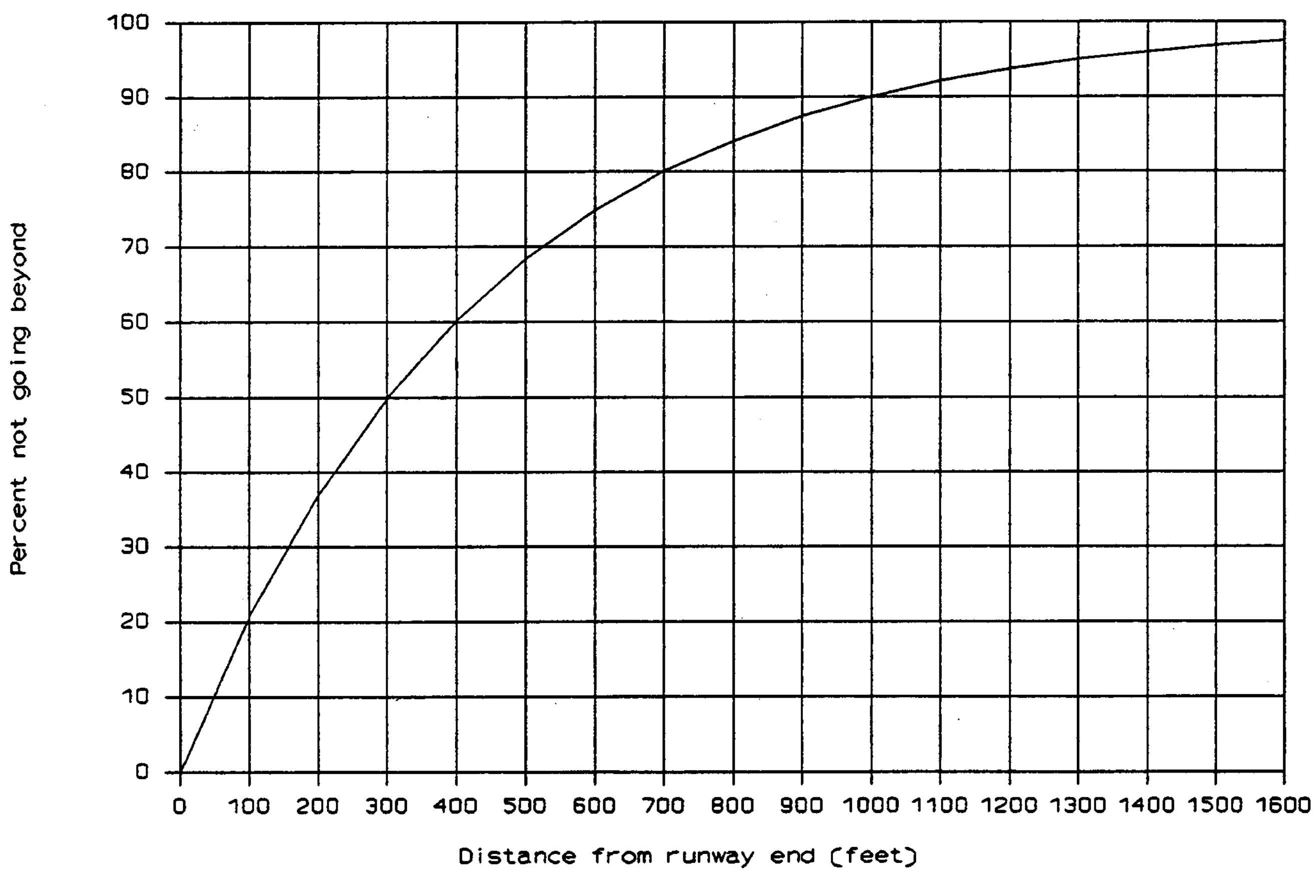


Figure A8-1. Approximate distance airplanes undershoot and overrun the runway end

Appendix 9. TAXIWAY AND TAXILANE DESIGN RATIONALE

1. INTRODUCTION. An airport operator is occasionally faced with the problem of having to cope with unusual terrain, local conditions, or the need to accommodate a specific airplane without accommodating other more demanding airplanes in the same airplane design group. This appendix provides the reasoning behind the selection of the various widths, clearances, and separations related to airplane physical characteristics. This rationale is usable, on a case-by-case basis, when local conditions or a specific airplane require modification of FAA airport design standards.

2. BACKGROUND AND RATIONALE. The minimum pavement widths, curve radii, and separations associated with airplane movement areas and airplane physical characteristics establish the taxiway system. Since the taxiway system is the transitional facility which supports airport operational capacity, the capability to maintain an average taxiing speed of at least 20 m.p.h. (30 km per hour) needs to be built into the system.

a. Separations. The parameters affecting separation criteria for taxiing airplanes, other than between a runway and its parallel taxiway, are wingspan and wingtip clearance. The need for ample wingtip clearance is driven by the fact that the pilots of most modern jets cannot see their airplane's wingtips.

(1) Taxiway to taxiway centerline separation, as shown in figure A9-1, is equal to 1.20 times the wingspan of the most demanding airplane plus 10 feet (3 m). This gives a wingtip clearance of 0.20 times the wingspan plus 10 feet (3 m). However, this separation may require an increase to accommodate minimum radius taxiway turns of 180 degrees, as shown in figure 4-10. The minimum acceptable radius is one which results in a maximum nosewheel steering angle (B) of 50 degrees. Appendix 10 discusses nosewheel steering angles.

(2) Taxiway centerline to object separation, as shown in figures A9-2 and A9-3, has the same wingtip clearances as taxiway to taxiway centerline separation. Thus, a minimum separation between a taxiway centerline and an object is 0.70 times the wingspan of the most demanding airplane, plus 10 feet (3 m).

(3) Taxiway object free area width is equal to twice the taxiway centerline to object separation.

(4) Taxilane centerline to object separation, as shown in figure A9-4, is equal to 0.60 times the wingspan of the most demanding airplane plus 10 feet (3 m). This gives a wingtip clearance of 0.10 times the wingspan plus 10 feet (3 m). This gives a wingtip clearance of one-half of that for an apron taxiway plus 5 feet (1.5 m). Reduced clearances are acceptable because taxi speed is very slow outside the movement area, taxiing is precise, and special operator guidance techniques and devices are normally present.

(5) Taxilane object free area width is twice the taxilane to object separation for a single lane width and 2.30 times the wingspan of the most demanding airplane plus 30 feet (9 m) for a dual lane width.

b. Taxiway Width. For a taxiway system to function safely and efficiently, the taxiway pavement needs to be of sufficient width to provide adequate clearance between the outside wheel and the pavement edge. This clearance permits normal deviations from the taxiway centerline or the intended path while taxiing at 20 mph (30 km per hour).

(1) Taxiway widths relate to the physical characteristics of airplanes. For example, a small high-performance jet airplane with long takeoff and landing requirement and a narrow undercarriage may operate on a relatively narrow taxiway. Conversely, a large airplane with short takeoff and landing capability, but with a wide undercarriage, requires a wider taxiway. Consequently, taxiway width is independent of runway length. The taxiway width should be at least equal to the sum of the undercarriage width plus two times the acceptable taxiway edge safety margin of the most demanding airplane.

(2) Table 4-1 specifies the clearance for tangents and curves, illustrated in figure A9-5, as taxiway edge safety margin.

c. Curves and Fillets. Taxiing around turns is difficult for pilots of airplanes with long wheelbases or when the cockpit is high and in front of the nosewheel. Appendix 10 covers detailed fillet design.

d. Taxiway Shoulders. Chapter 8 contains the design considerations for taxiway shoulders.

e. Taxiway Safety Area. To provide room for rescue and firefighting operations, the taxiway safety area width equals at least the wingspan of the most demanding airplane.

3. EXIT TAXIWAY LOCATION. Table A9-1 presents cumulative percentages of airplanes observed exiting existing runways at specific exit taxiway locations. In general, each 100-foot (30 m) reduction of the distance from the threshold to the exit taxiway reduces the runway occupancy time by approximately 3/4 of a second for each airplane using the exit. Conversely, the runway occupancy time of each additional airplane now overrunning the new exit location is increased by approximately 3/4 of a second for each 100 feet (30 m) from the old location to the next available exit.

For example, the percent of airplanes exiting at or before an exit located 4,000 feet (1220 m) from the threshold are:

a. When the runway is wet, 100 percent of A, 80 percent of B, 1 percent of C, and 0 percent of D airplanes;

b. When the runway is dry and the exit is right angled, 100 percent of A, 98 percent of B, 8 percent of C, and 0 percent of D airplanes; and

c. When the runway is dry and the exit is acute angled, 100 percent of A, 98 percent of B, 26 percent of C, and 3 percent of D airplanes.

When selecting the location and type of exit both the wet and dry runway conditions along with a balance between increases and decreases in runway occupancy time should be considered.

Table A9-1. Exit taxiway cumulative utilization percentages

DISTANCE THRESHOLD TO EXIT	WET RUNWAYS				DRY RUNWAYS							
	RIGHT & ACUTE ANGLED EXITS				RIGHT ANGLED EXITS				ACUTE ANGLED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0 ft (0 m)	0	0	0	0	0	0	0	0	0	0	0	0
500 ft (152)	0	0	0	0	0	0	0	0	1	0	0	0
1000 ft (305 m)	4	0	0	0	6	0	0	0	13	0	0	0
1500 ft (457 m)	23	0	0	0	39	0	0	0	53	0	0	0
2000 ft (610 m)	60	0	0	0	84	1	0	0	90	1	0	0
2500 ft (762 m)	84	1	0	0	99	10	0	0	99	10	0	0
3000 ft (914 m)	96	10	0	0	100	39	0	0	100	40	0	0
3500 ft (1067 m)	99	41	0	0	100	81	2	0	100	82	9	0
4000 ft (1219 m)	100	80	1	0	100	98	8	0	100	98	26	3
4500 ft (1372 m)	100	97	4	0	100	100	24	2	100	100	51	19
5000 ft (1524 m)	100	100	12	0	100	100	49	9	100	100	76	55
5500 ft (1676 m)	100	100	27	0	100	100	75	24	100	100	92	81
6000 ft (1829 m)	100	100	48	10	100	100	92	71	100	100	98	95
6500 ft (1981 m)	100	100	71	35	100	100	98	90	100	100	100	99
7000 ft (2134 m)	100	100	88	64	100	100	100	98	100	100	100	100
7500 ft (2686 m)	100	100	97	84	100	100	100	100	100	100	100	100
8000 ft (2438 m)	100	100	100	93	100	100	100	100	100	100	100	100
8500 ft (2591 m)	100	100	100	99	100	100	100	100	100	100	100	100
9000 ft (2743 m)	100	100	100	100	100	100	100	100	100	100	100	100

A - Small, single engine 12,500 lbs (5 700 kg) or less
B - Small, twin engine 12,500 lbs (5 700 kg) or less
C - Large 12,500 lbs (5 700 kg) to 300,000 lbs (136 000 kg)
D - Heavy 300,000 lbs (136 000 kg)

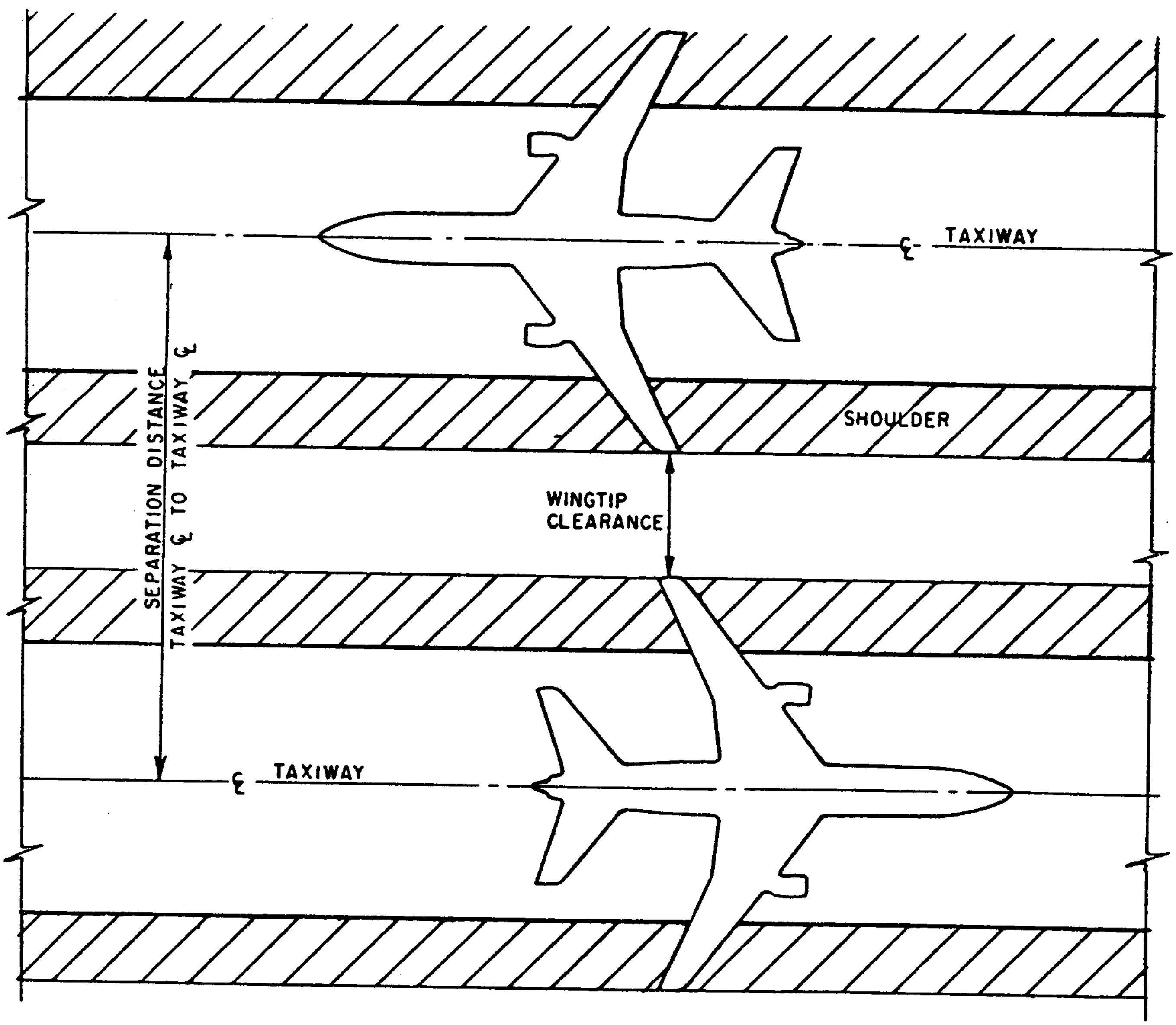


Figure A9-1. Wingtip clearance - parallel taxiways

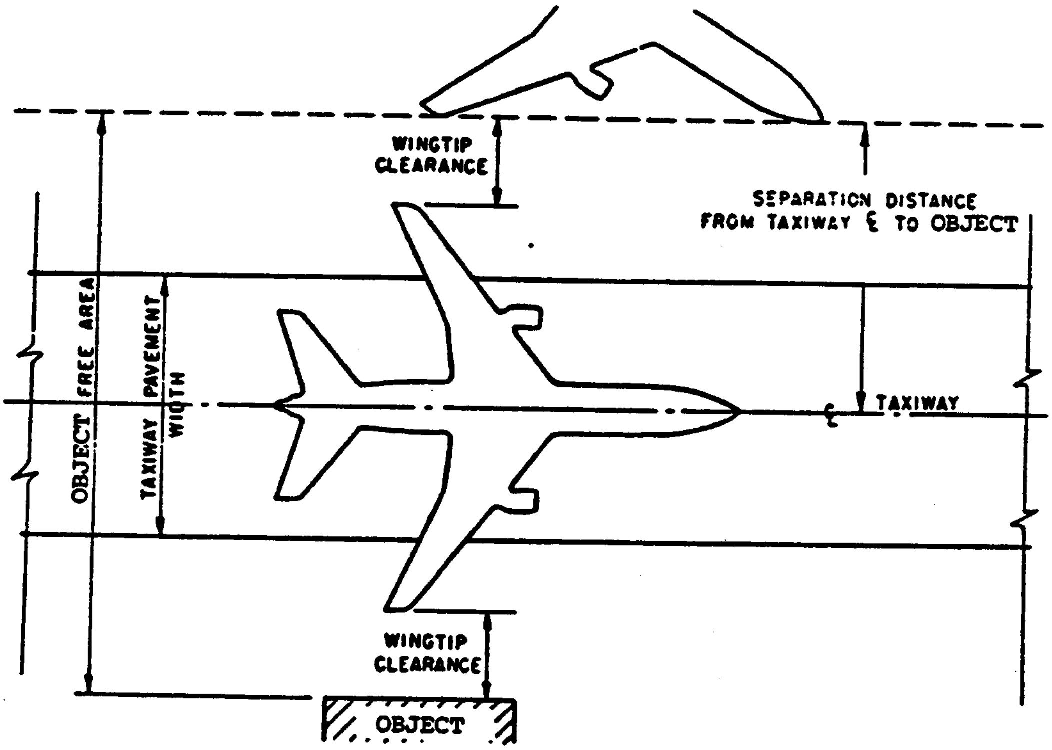


Figure A9-2. Wingtip clearance from taxiway

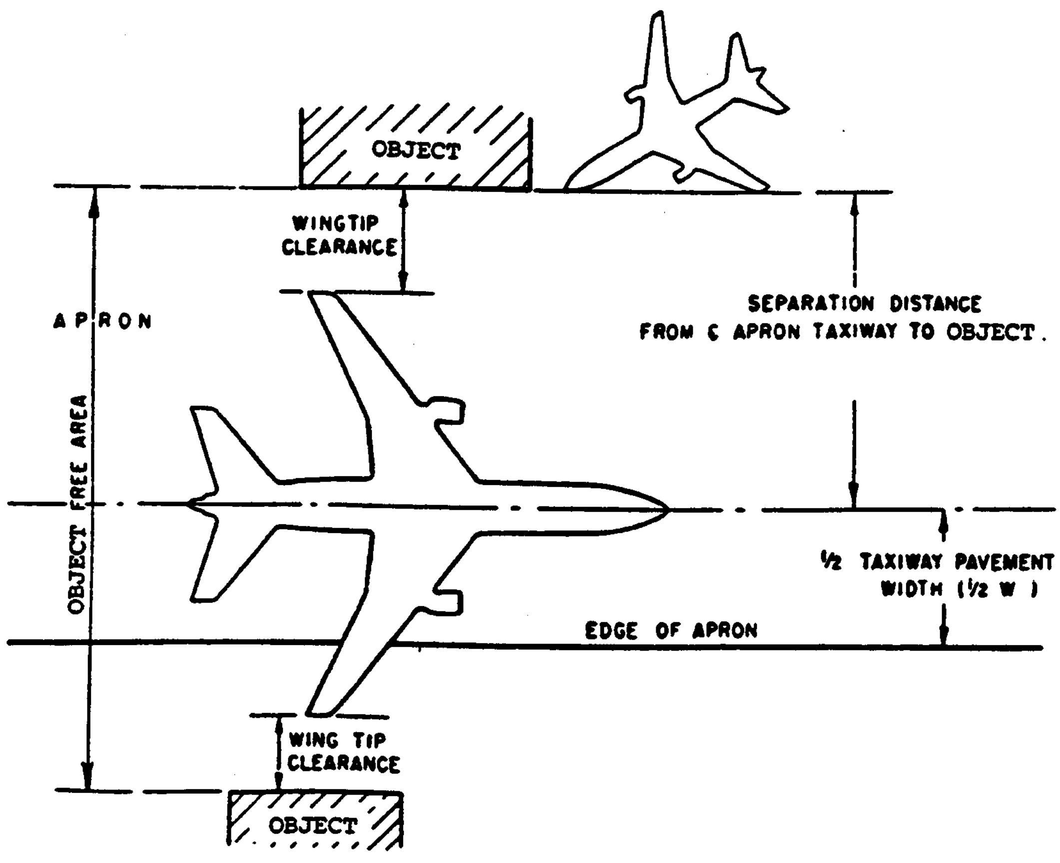


Figure A9-3. Wingtip clearance from apron taxiway

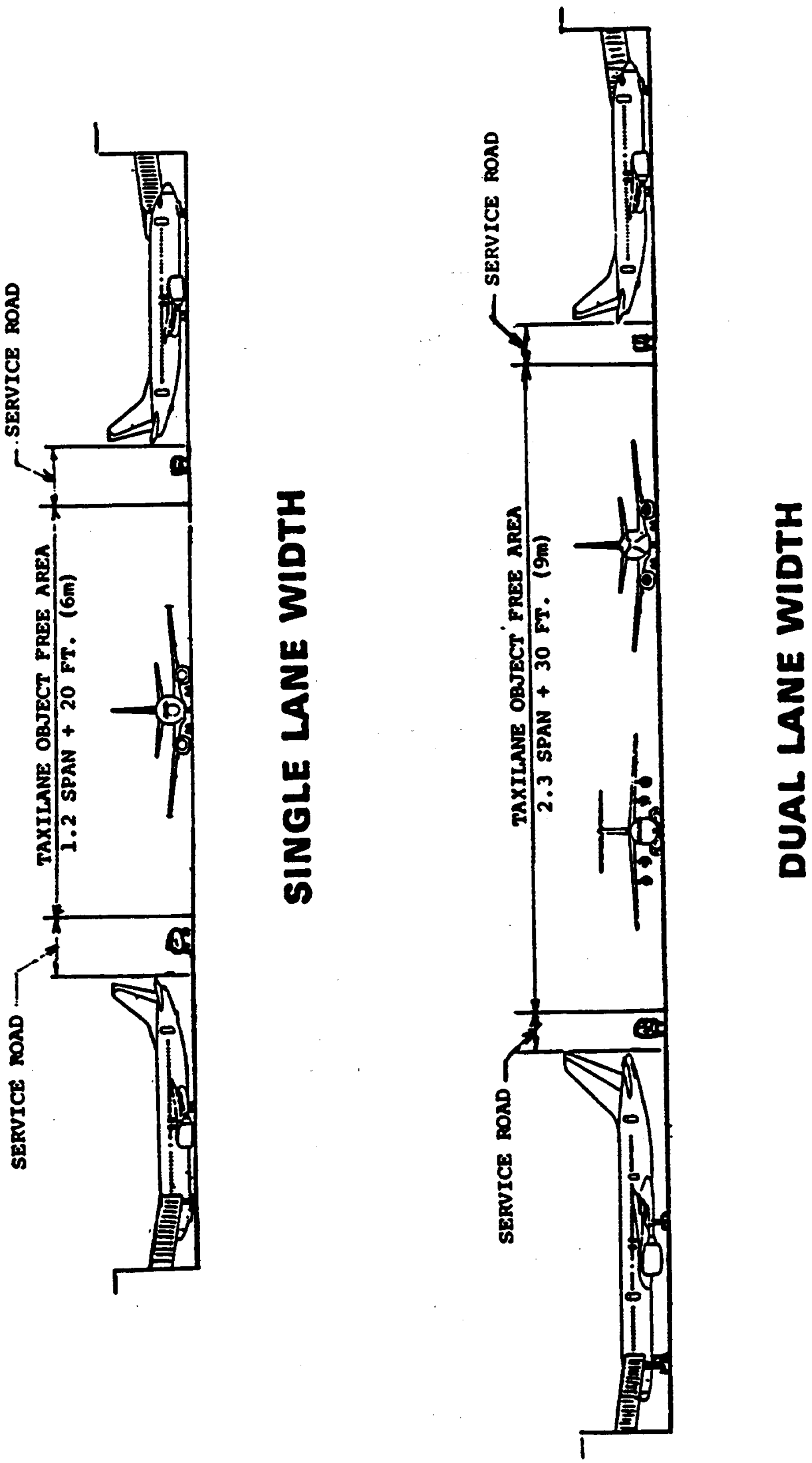


Figure A9-4. Wingtip clearance from taxilane

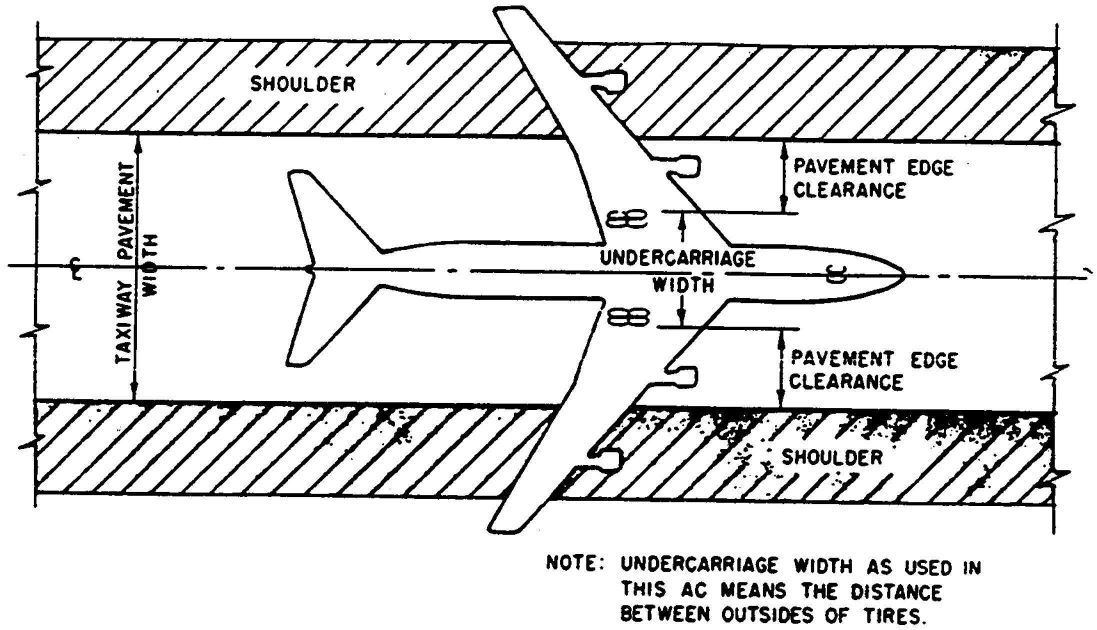


Figure A9-5. Pavement edge clearance on tangent

4. WINGTIP TRACE. The following equations calculate the rectangular coordinates of points on the wingtip trace.

$x = x_c - t \cos (A - B) \pm .5s \sin (A - B)$

$y = y_c + t \sin (A - B) \pm .5s \cos (A - B)$

x_c and y_c are the rectangular coordinates of a selected point on the centerline pavement markings. One centerline point is required for each trace point.

A is the angle formed by the tangent to the centerline pavement markings and the longitudinal axis of the airplane at the selected point. Appendix 10 provides instructions for obtaining this angle.

B is the angle direction of the centerline pavement markings at the select centerline point.

t is the longitudinal distance from the center of airplane cockpit to the airplane wingtip.

s is the airplane wingspan.

To obtain the wingtip clearance trace, add the wingtip clearance to the wingtip trace.

a. The airport design computer program described in appendix 11 provides the OFA clearance fillet requirement directly.

(1) Figure A9-6 depicts the McDonnell-Douglas MD-88 wingtip clearance traces for a 100-foot (30.5m) radius of turn with centerline pavement markings.

(2) Figure A9-7 depicts the McDonnell-Douglas MD-88 wingtip clearance trace for a 100-foot (30.5 m) radius of turn with offset centerline pavement markings located on a 120-foot (30.5 m) radius arc.

(3) Figure A9-8 depicts the Boeing 727-200 wingtip clearance trace for a 100-foot (30.5 m) radius of turn with offset centerline pavement markings located on a 120-foot (30.5 m) radius arc.

(4) Figure A9-9 depicts the Boeing 727-100 wingtip clearance trace for a 100-foot (30.5 m) radius of turn with offset centerline pavement markings located on a 120-foot (30.5 m) radius arc.

b. The computer program treats the offset taxilane pavement markings arcs as five sections:

(1) A tangent section;

(2) A circular section comprised of a $\pm \cos^{-1}$(turn radius/offset radius) degree angle (same sign as the intersection angle) and a 0-foot radius;

(3) the offset arc (a circular section comprised of the intersection angle and the offset radius);

(4) A circular section comprised of a $\pm \cos^{-1}$(turn radius/offset radius) degree angle (apposite sign as the intersection angle) and a 0-foot radius; and

(5) A tangent section.

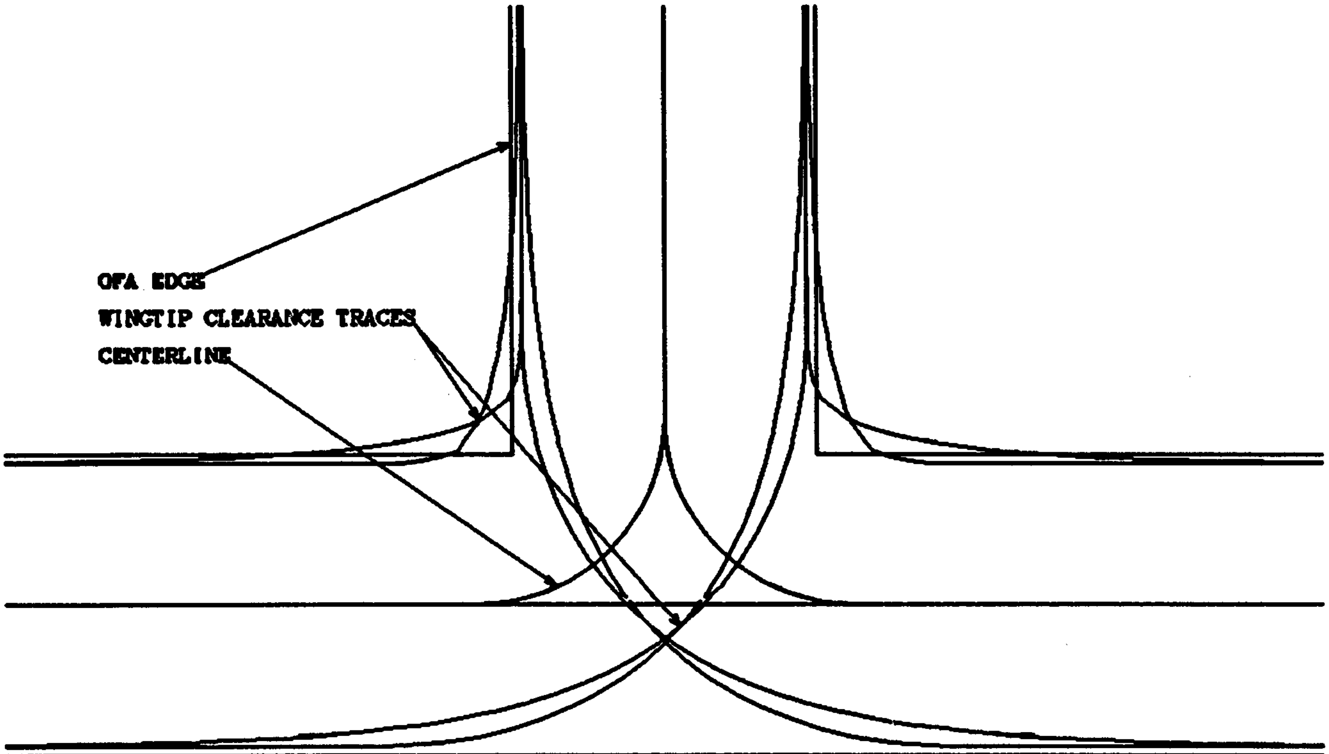


Figure A9-6. McDonnell-Douglas MD-88 wingtip clearance trace for a 100-foot (30.5 m) radius centerline

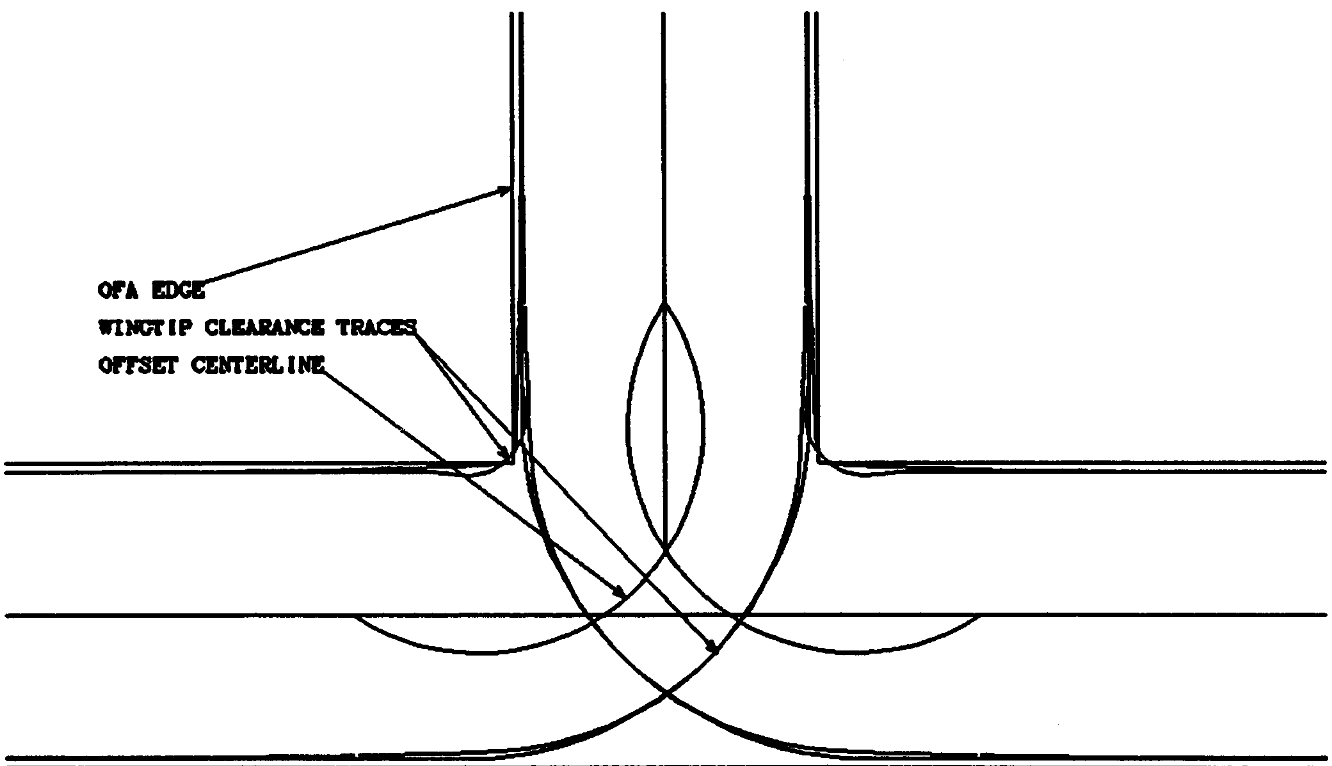


Figure A9-7. McDonnell-Douglas MD-88 wingtip clearance trace for a 120-foot (36.5 m) radius offset centerline

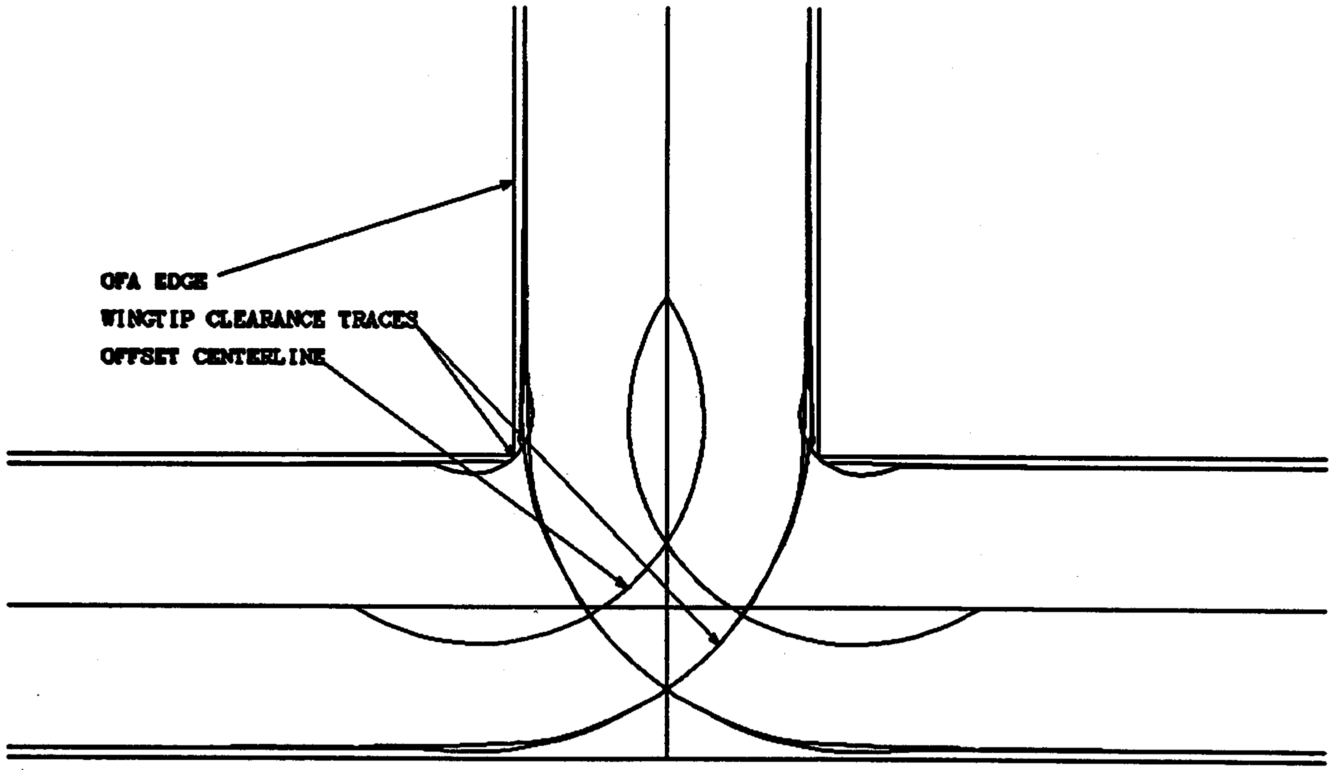


Figure A9-8. Boeing 727-200 wingtip clearance trace for a 120-foot (36.5 m) radius offset centerline

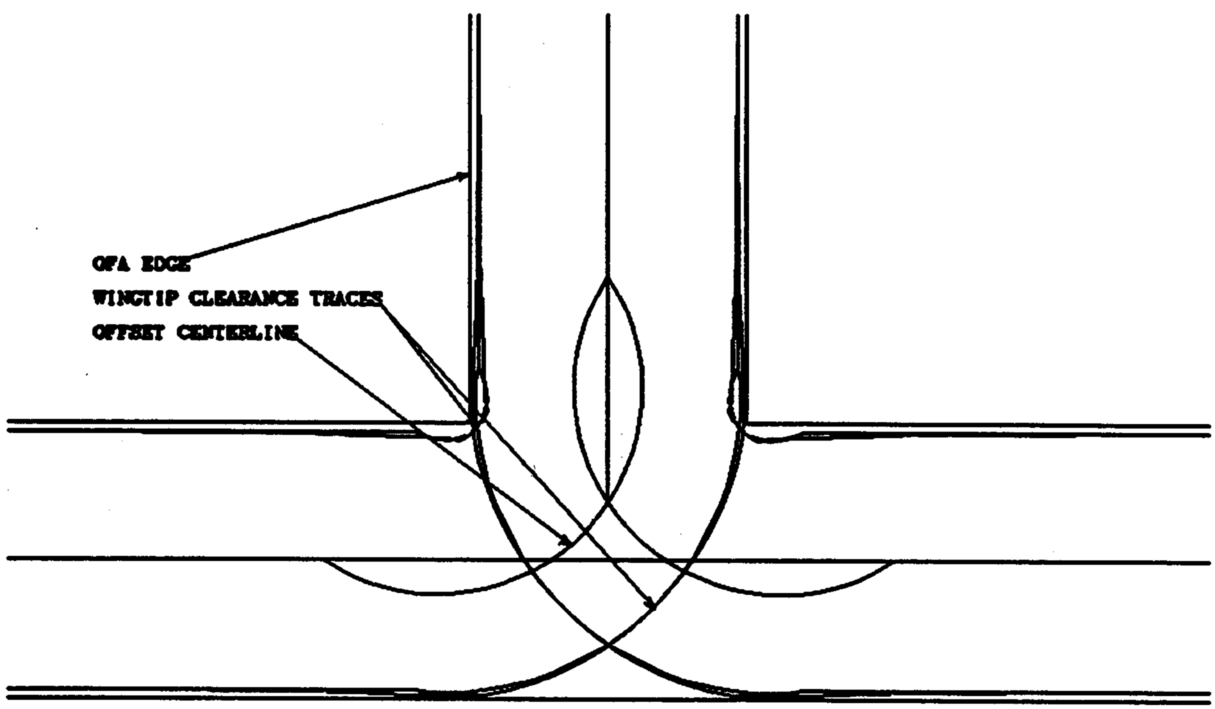


Figure A9-9. Boeing 727-100 wingtip clearance trace for a 120-foot (36.5 m) radius offset centerline

Appendix 10. TAXIWAY FILLET DESIGN

1. INTRODUCTION. This appendix details the methodology for the design of fillets for airport taxiways. This methodology is equally applicable for either the judgmental oversteering and the maintaining cockpit over centerline method of fillet design. The computer program cited in Appendix 11 computes these fillet dimensions for the maintaining cockpit over centerline method of fillet design. Figures A10-1 and A10-2 illustrate the terms and symbols used in the following equations:

a. Angle A. The angle formed by the tangent to the guideline and the longitudinal axis of airplane at point N.

(1) For R less than d:

$$A = 2 \tan^{-1}[x \tan(\tan^{-1}((\tan(.5A_o) - R/d)/x) + 28.648xS/R) + R/d]$$

(2) For R equal to d:

$$A = 2 \tan^{-1}[1/(1/(\tan(.5A_o) - 1) - .5S/R) + 1]$$

(3) For R greater than d:

$$A = 2 \tan^{-1}[y(2/(1 - z) - 1) + R/d]$$

(4) For tangent section:

$$A = 2 \tan^{-1}[\tan(.5A_t)/2.7183^{S/d}]$$

b. Angle A_{max}. Angle A with point N at the point of tangency (P.T.) or at the point of change of curvature (P.C.C.). At the end of a long curve:

$$A_{max} = \sin^{-1}(d/R)$$

c. Angle A_o. Angle A with point N at the point of curvature (P.C.). The angle A_o at the end of a long tangent section is zero (0) degrees.

d. Angle A_t. Angle A with point N at the point of tangency (P.T.).

e. Nosewheel Steering Angle (B). The angle the nosewheel makes with the longitudinal axis of the airplane. In the design of pavement fillets, check to ensure that the nosewheel steering angle does not exceed 50 degrees. If exceeded, choose a larger radius of arc (R).

$$B = \tan^{-1}[(w/d)\tan A]$$

$$B_{max} = \tan^{-1}[(w/d)\tan A_{max}]$$

f. Airplane Datum Length (d). The distance between point N and the center of the main undercarriage.

g. Radius of Fillet Arc (F). The radius of the fillet measured from the center of the taxiway longitudinal curvature (0). To provide an acceptable taxiway edge safety margin (M), the radius of fillet should be equal to or less than:

$$F = (R^2 + d^2 - 2Rd \sin A_{max})^{.5} - .5u - M$$

h. Length of Lead-in to Fillet (L). The distance from the P.T. to the end of the fillet. To provide an acceptable taxiway edge safety margin (M), the length of lead-in to the fillet should be equal to or greater than:

$$L = d\{\ln[4d \tan(.5A_t)/(W - u - 2M)]\} - d$$

i. Taxiway Edge Safety Margin (M). The minimum distance between the outside of the airplane wheels and the pavement edge. The minimum acceptable taxiway edge safety margin is given in table 4-1.

j. Point N. The point beneath the longitudinal axis of the airplane which tracks the guideline on the ground. Point N is located:

(1) For judgmental oversteering, beneath the longitudinal axis of the airplane at a distance from the center of the main undercarriage equal to the following. This distance provides a safety margin to compensate for the lack of positive guidance.

(a) Widening on only one side:

$$d = (R^2 - (R + .5W - 2M)^2 + w^2)^{.5}$$

(b) Widening symmetrical:

$$d = (R^2 - (2R - F - 2M)^2 + w^2)^{.5}$$

(2) For cockpit over centerline, beneath the cockpit of the airplane.

k. Radius of Arc (R). The radius of the arc at point N measured from center of curvature (O) to the point N.

l. Distance S. The distance from the P.C. to the point N along the arc for arc sections and from the P.T. to the point N along the tangent for tangent sections.

m. Undercarriage Width (u). The distance between the airplane's outer main wheels, including the width of the wheels. For airport design purposes, when the dimension "u" is not available, assume "u" to be 1.15 times the airplane's main gear track.

n. Wheelbase (w). The distance between the nosewheel and the center of the main undercarriage.

o. Taxiway Width (W). The taxiway pavement width on the tangent section. The taxiway width should be greater than the sum of the undercarriage width plus two times the acceptable taxiway edge safety margin (M).

p. Symbol x.

$x = (1 - (R/d)^2)^{.5}$

q. Symbol y.

$y = ((R/d)^2 - 1)^{.5}$

r. Symbol z.

$z = 2.7183^{yS/R}(R/d + y - \tan(.5A_o))/(R/d - y - \tan(.5A_o))$

2. EXAMPLE NO. 1, JUDGMENTAL OVERSTEERING. Given: Airplane wingspan 196 feet (59.7 m), wheelbase 84 feet (25.6 m), undercarriage width 41 feet (12.5 m), and R = 150 feet (45 m) for 180 degree turn. Taxiway width is 75 feet (23 m), fillet radius, widening on only one side, is 97 feet (29 m), and lead-in to fillet is 250 feet (75 m).

Step 1 - Acceptable M = 15.0 feet (4.5 m)

Step 2 - Calculate Amax = 27.3 degrees (27.2 degrees)

Step 3 - Calculate Bmax = 32.2 degrees (32.6 degrees)

Step 4 - Calculate provided M = 15.8 feet (4.8 m)

3. EXAMPLE NO. 2, MAINTAINING COCKPIT OVER CENTERLINE. Given: Airplane wingspan 196 feet (59.7 m), wheelbase 84 feet (25.6 m), distance between main undercarriage and cockpit 90 feet (27.4 m), undercarriage width 41 feet (12.5 m), and cockpit following R = 150 feet (45 m) for 180 degree turn. Taxiway width is 75 feet (22 m).

Step 1 - Acceptable M = 15.0 feet (4.5 m)

Step 2 - Calculate A_{max} = 36.4 degrees (37.0 degrees)

Step 3 - Calculate B_{max} = 34.5 degrees (35.1 degrees)

Step 4 - Calculate F_{max} = 85.2 feet (25.2 m)

Step 5 - Calculate L_{min} = 215 feet (60.2 m)

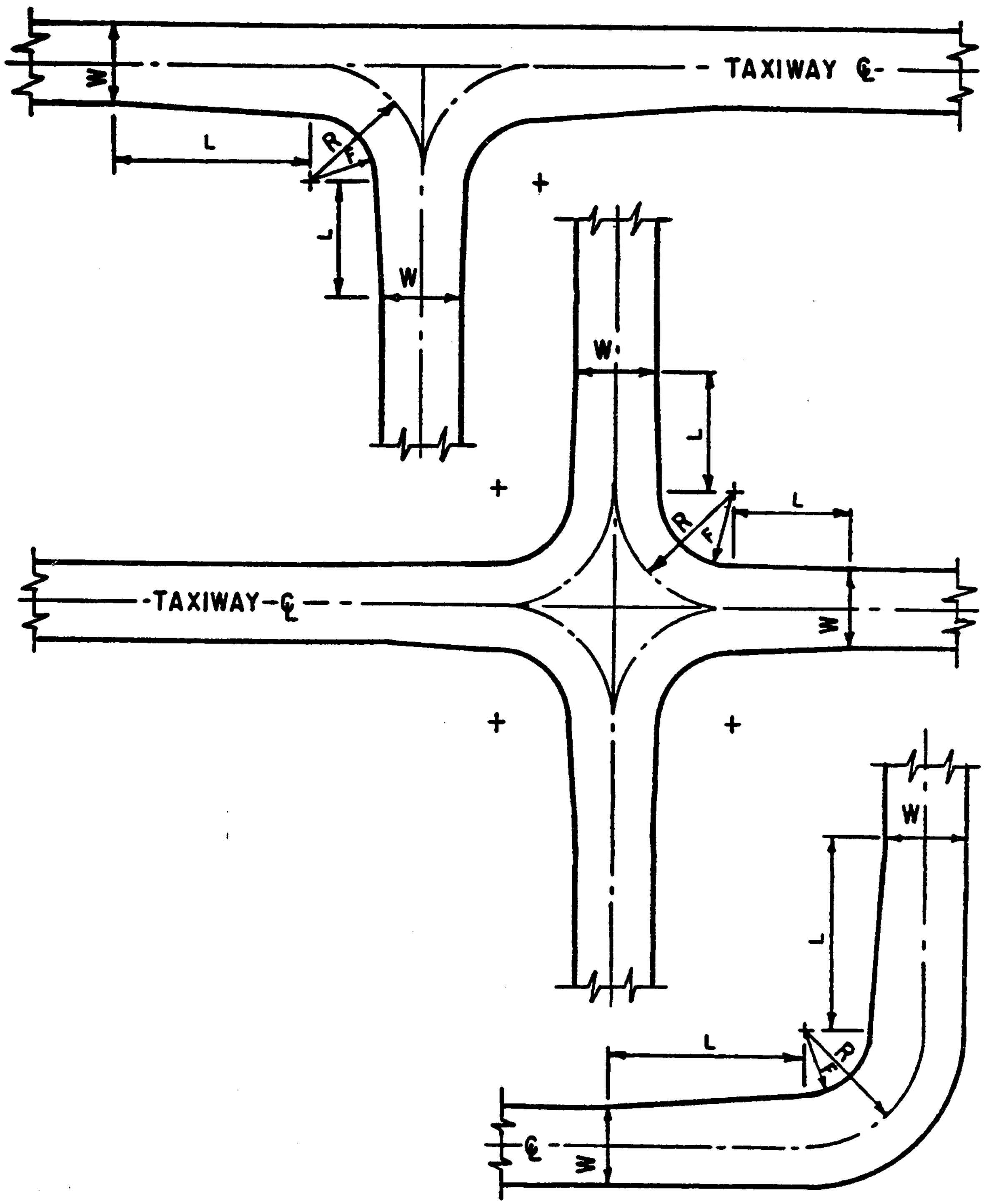


Figure A10-1. Taxiway intersection details

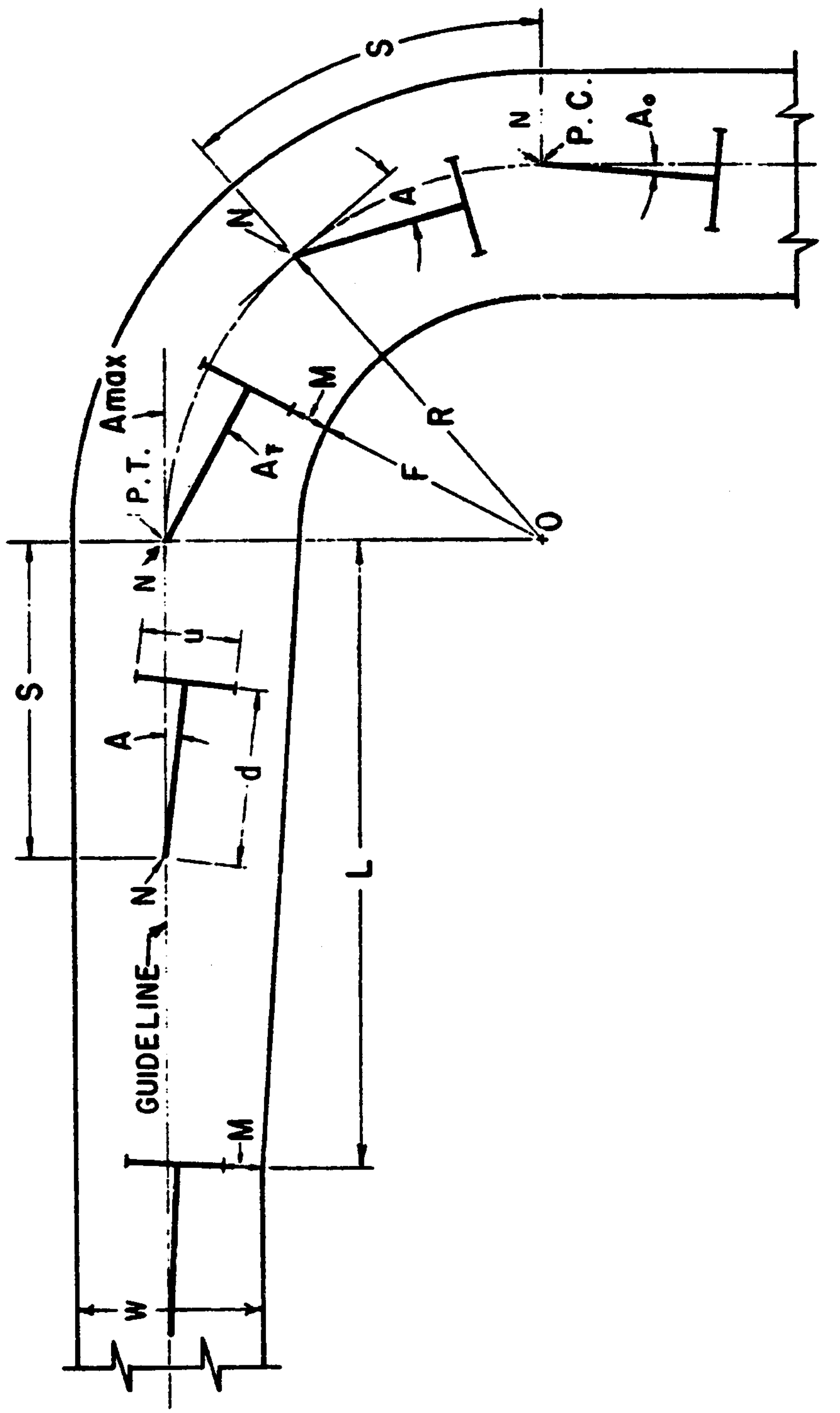


Figure A10-2. Depiction of symbols

Appendix 11. COMPUTER PROGRAM

1. <u>AIRPORT DESIGN (FOR MICROCOMPUTERS) VERSION 4.1</u>. Airport Design (for microcomputers) version 4.1 provides:

a. Width and clearance standard dimensions for runway, taxiway, taxilane, and associated facilities;

b. Recommended runway lengths;

c. Runway wind coverage analysis;

d. Files for editing, printing, and plotting windroses with AutoCAD and Design CAD2D (formally Prodesign II);

e. Files loadable into WordPerfect, Microsoft Word, and other CAD/CAM systems;

f. Taxiway exit, intersection, and curve configurations;

g. Airplane wingtip clearance analyses;

h. Airport capacity and delay for long range planning; and

i. Declared distance lengths.

2. <u>HOW TO OBTAIN A COPY OF AIRPORT DESIGN (FOR MICROCOMPUTERS) VERSION 4.1</u>. Airport Design version 4.1 is available for downloading from the Office of Airport Safety and Standards Electronic Bulletin Board System.

Telephone number:	(202) 267-5205
Data bits:	8
Parity:	(N)one
Stop bits:	1
Buad rate:	300/1200/2400/9600/14400

3. <u>REQUIREMENTS</u>. Airport Design version 4.1 runs on the IBM PC family of computers and all true IBM compatible. It requires DOS of 3.1 or higher and at least 640K of RAM.

4. <u>SETUP ON A MICROCOMPUTER</u>. This program is composed of seven files namely AD.EXE, HELP.TXT,HELPE.PLT,HELPM.PLT,WINDDXF.AD, WINDPD1.AD, and WINDPLT.AD. These files must be located into a subdirectory. If you have Microsoft Windows, run this program as a Non-Windows Application to make use of the Windows graphic printing applications. Make the subdirectory, where the program files are located, the start-up directory. The working directories should be other than the start-up directory. Adjust the graphic colors with Shift F4, the size with Page Up and Page Down, and the location with the cursor keys of the graphic displayed on the screen as required by the windows application.

5. <u>RUN AIRPORT DESIGN PROGRAM</u>. The first window displayed on the screen upon executing AD.EXE is the airport design task selection window. Press the task number listed in the left margin or scroll to the task line and press <—┘ to select a task from this list.

6. <u>HOT KEYS</u>. The HOT KEYS are as follows:

<—┘ advances the program one step.
Esc retreats the program one or more steps.
Alt X exits the program.
Ctrl C (Controlled Crash) aborts the program.

Hot keys, when listed at the bottom of screen, are:

F1-Help - Press F1 and scroll for more program help instructions. When the help instructions are on the screen, press H or the task number to fast scroll to the top of the HOT KEYS or the top of the task help instructions. Press <—┘ or Esc to end the help section.

F2-Save - Press F2 and enter output file name to create a DOS text *.TXT file. Scroll to preview the entire file. Press <—┘ or Esc to end the preview section. These files are retrievable into WordPerfect, Microsoft Notepad, and back into the task which created the file.

F3-Retrieve or F3-Retrieve/Clear - Press F3 or F5 to retrieve a file. When files and directories are listed on the screen and hot key F3 is listed on the bottom of the screen, type or scroll to the file name and press F3 to retrieve the highlighted file or press Esc to return to where the program was when F3 or F5 was pressed. When a file is displayed on the screen and hot key F3 is listed on the bottom of the screen press F3 to retrieve the file. When files and directories are listed on the screen, all of the F5-Files functions may also be executed.

F3-Retrieve/Clear - Press Shift F3 to clear the wind observation data.

F4-Dir/Color - Press F4 and enter the drive letter to change the working drive. Press Shift F4 to change the graphic screen colors (Background and Pen colors). Press <—┘ or Esc to end the color change section.

F5-Files - Press F5 to list files and directories and to add hot keys F3, F4, F6, and F7 to the bottom of the screen. When files and directories are listed on the screen, type or scroll to the file or directory name and press <—┘ to preview the highlighted file or change the highlighted directory or press Esc to return to where the program was when F5 was pressed. Line only HP plotter (HPGL) files are previewed in graphic format. To preview a HPGL file in the DOS text format, press <—┘ while "Please wait" is displayed on the screen. Press <—┘ or Esc to end the preview section.

F6-Delete - Type or scroll to the file name and press F6 to delete the highlighted file. Press F6 to delete a file being previewed on the screen.

F7-Print - When files and directories are listed on the screen and hot key F7 is listed on the bottom of the screen, type or scroll to the file name and press F7 to print the highlighted file. Press F7 to print the file being previewed on the screen.

F8-Quit - Press F8 to exit the program.

F9-PLT/PD1/DXF - Press F9 to create a windrose in the HP 7440A ColorPro plotter (HPGL) file format. Press Shift F9 to create a windrose in the Design CAD2D (formerly Prodesign II) file format. Press Alt F9 to create a windrose in the AutoCAD Drawing Interchange file format (DXF). Press <—┘ or Esc to end the preview section. The HPGL files are loadable into WordPerfect, Microsoft Word, and other CAD/CAM systems. The PD1 files are loadable into Design CAD2D (formerly Prodesign II). Call (918) 825-4844 for information on Design CAD2D.

F10-Find - Press F10 to find a string of characters in a file.

F10-Next - Press F10 to move to the next taxiway section. Press Esc to move back to the previous taxiway section.

7. RUNWAY AND TAXIWAY WIDTH AND CLEARANCE STANDARD DIMENSIONS. Task 1 calculates site specific runway, taxiway, taxilane, and other airport item's standard width and clearance dimensions. To obtain these dimensions:

a. Select task 1 (Item N1) from the airport design task selection window. Update the data items listed on the airport design airplane and airport data window (see figure A11-3). A change in one item may change one or more items down the list. Select items for updating starting from the top and work down the list. Press the item letter listed in the left margin, or scroll to the item line and type in the data, or press <—┘ to select an item. Press the data number or letter listed in the left margin or scroll to the data line and press <—┘ to select an item on the subtables. The following explains some of the data items:

(1) Item B. Changing the airplane design group will change the airplane wingspan to the maximum wingspan for that group. This is the wingspan used for the standard design group method of airport design. A small airplane is an airplane of 12,500 lbs (5 700 kilograms) or less maximum takeoff weight. A large airplane is an airplane of over 12,500 lbs (5 700 kilograms) maximum takeoff weight.

(2) Item C. Changing the airplane wingspan will adjust the airplane design group automatically. For airplanes with folding wingtips, input the taxiing wingspan(s) for taxiway and taxilane width and clearance standard dimension (Item N3). Input the takeoff and landing wingspan for all other width and clearance standard dimensions (Item N2).

(3) Item D. The primary runway end is the runway end the user selected as the primary end.

(4) Item I. The undercarriage width is the distance between the airplane's outer main wheels, including the width of the wheels. When this distance is not available, use 1.15 times the airplane's main gear track.

When the data items are updated, press F2, enter the output file name, and press <—┘ or Esc to end the preview section. Line items with two numbers represent the calculated design values for the rationale method (column one) and the airport reference code method (column two) (see figures A11-4 and A11-5).

8. RECOMMENDED RUNWAY LENGTHS. Task 2 from the airport design task selection window calculates the recommended runway length for airport design. Press F2 to save the recommended runway lengths and then print them by pressing F7. Refer to AC 150/5325-4, Runway Length Requirements for Airport Design, for details on runway length. The publication "Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days" (Climatography of the United States No.81) is the official source for the mean maximum temperature for the hottest month. This temperature is presented by station under the heading "Normal Max." The higher of these values should be selected to represent the hottest month. The latest data, averaged over a period of 30 years, may be obtained from the National Climatic Data Center, Federal Building, Asheville, North Carolina 28801. Specify the state(s) when ordering. Price is $2.00 per state plus a $5.00 service and handling charge.

9. STANDARD WIND ANALYSIS. This task calculates the wind coverage for up to a six runway configuration. Figure A11-6 displays a two bi-directional runway configuration analysis printout and figure A11-8

displays a one uni-directional runway configuration analysis printout.

a. To preform the wind analysis, select task 3 from the airport design task selection window, press Shift F3 to clear the wind data, and enter the wind data either from the keyboard, a DOS text file (retrieve by pressing F3), or a combination of both. Enter 60 knot tailwind component for bi-directional runways. Press F2 and enter the output file name to create a DOS text windrose file. Scroll to preview the entire file. Press F9 to create a windrose in the HP 7440A ColorPro plotter (HPGL) file format (PLT). Press Shift F9 to create a windrose in the Design CAD2D (formerly Prodesign II) file format (PD1). Press Alt F9 to create a windrose in the AutoCAD Drawing Interchange file format (DXF). Press <—┘ or Esc to end the preview section. The PLT files are loadable into WordPerfect, Microsoft Word, and other CAD/CAM systems. The PD1 files are loadable into Design CAD2D or Prodesign II.

b. The DOS text file may have an unlimited number of lines with a maximum of 120 columns each.

(1) The first 80 columns of the third line contain the location name. The third, fourth, etc., words (numbers) of the fourth, fifth, and sixth lines are the runway orientations, the crosswind components, and the tailwind components of the first, second, etc., runways.

(2) Lines 12 through 48 are wind observation data. The first word is the wind direction, the second word is the number of 0-3 knot wind observations, the third word is the number of 4-6 knot wind observations, etc. For words which are not numbers or are omitted, the number of wind observations is zero. All other data are ignored. The WIND.PRN file in the Airport Design package is an example of this DOS text file.

c. Wind data in this FAA format on disk can be purchased from the National Climatic Data Center (NCDC), Federal Building, Asheville, NC 28801 at a cost of $200.00 per summary plus an $11.00 service and handling charge. A summary can be ordered with several tables. One table for each combination of all weather and various combinations of ceiling and visibility for monthly, seasonal, and annual periods, with 24 hourly and selected time-of-day observations. Ask for the wind data summary in the FAA format for use with the Airport Design Microcomputer Program. For details on availability, call (704) 254-6283 (CLIMATE).

10. TAXIWAY DESIGN. Task 4 from the airport design task selection window contains seven subtasks. Figure A11-10 and appendix 10 depict the nomenclature used in this task.

a. Subtask 1 calculates the data required for laying out circular and spiral curves by the offset method. To calculate this data, select subtask 1, the type of section, and update the data items. Due to the redundance in data items, more than one datum item may change with each data entry; the number of * after the data items define which data items will change to accommodate the new entry. When the data items are updated, press F2, enter the station interval and the file name, preview the output file, and press <—┘ or Esc to end the preview.

b. Subtasks 2 through 5 calculate the offset distances from centerline to edge of pavement or object using the maintaining cockpit over centerline or the nosewheel on centerline method of pavement fillet design.

(1) To calculate the offset distances, select a subtask (2 through 5) and define the design airplane and conditions at the entrance of station 1 by updating the data items. The steering angle is the angle formed by the tangent to the guideline (centerline marking or lighting) and the longitudinal axis of the airplane. Angle A on figure A10-2 depicts the steering angle. All longitudinal distances are measured parallel to the airplane's longitudinal axis. Press F10 when the data items are updated.

(2) Subdivide the taxiway/taxilane centerline into sections (tangent, circular, and spiral). Select the type of section 1 and update the data items for section 1. Except for the last section, press F10 when the data items are updated. For the last section, press F2 when the data items are updated. When F10 is pressed, select the type of the next section and update the data items for that section. When F2 is pressed, enter the station interval and the file name, preview the output file, and press <—┘ or Esc to end the preview.

c. Subtask 6 creates a HP 7440A ColorPro plotter (HPGL) offset distance file with a PLT extension. To create this file, select subtask 6, retrieve a file created with subtask 2 through 5, enter the output file name, and press <—┘ or Esc to end the preview section. The HPGL files are loadable into WordPerfect, Microsoft Word, and other CAD/CAM systems.

d. Subtask 7 creates a Design CAD2D offset distance file with a PD1 extension. To create this file, select subtask 7, retrieve a file created with subtask 2 through 5, enter the output file name, and press <—┘ or

Esc to end the preview section. The PD1 file are loadable into Design CAD2D or Prodesign II.

e. Subtasks 8, 9, and 0 create DOS text files of the centerline, left offset, and right offset X, Y coordinates. To create these files, select subtask 8, 9, or 0, retrieve a file created with subtask 2 through 5, enter the output file name, and press <—┘ or Esc to end the preview section.

f. Subtask A creates a file in the AutoCAD Drawing Interchange file format (DXF) from a subtask 2 through 5 file. To create this file, select subtask A, retrieve a file created with subtask 2 through 5, enter the output file name, and press <—┘ or Esc to end the preview section.

g. To familiarize yourself with the taxiway design task, design the taxiway pavement fillet depicted in figure 4-4 and the exit taxiway depicted in figure 4-13.

11. AIRPORT CAPACITY AND DELAY FOR LONG RANGE PLANNING. Task 5 from the airport capacity and delay for long range planning task selection window approximates the airport capacity and delay. Press F2 to save the approximations. Refer to AC 150/5060-5, Airport Capacity and Delay, for details on airport capacity and delay. Import graphics file HELPE.PLT or HELPM.PLT into WordPerfect or Microsoft Word and print to obtain a hard copy of the runway-use configuration sketches.

12. DECLARED DISTANCE LENGTHS. Task 6 from the airport design task selection window calculates the declared distance lengths. See appendix 14 for details on declared distances. Declared distance lengths may be calculated for standard or modified RSA and ROFA lengths. Press W within task 6 to alternate between the standard and the modified RSA and ROFA lengths applications. Figure A11-11 depicts the nomenclature used in this task.

a. The declared distance lengths obtained from the standard RSA and ROFA lengths application are displayed to scale on the screen except for the ARC C-III and D-III runway widths, and the ARC D-1 through D-VI+ RSA widths. Go to task 1 and enter the 150,000 pounds (68 100 kg) weight entry to display the ADG C-III and D-III runway width to scale and enter the airport elevation to display the ADG D-I through D-VI+ RSA width to scale.

b. The declared distance lengths obtained from the modified RSA and ROFA lengths are displayed to scale by setting items A through D for the standard RSA and ROFA length application, as above, and then switching to the modified RSA and ROFA length application.

c. The dashed lines display the clearway. When present, the clearway extends between the TORA far end and the TODA far end. (The dotted lines display FAR Part 77 primary and approach surfaces and are provided for informational purposes only. The primary surface extends out to 200 feet (60 m) beyond the runway ends or out to the far ends of TODA, whichever is further.)

d. Items A through D on the modified RSA and ROFA lengths application. Enter the RSA and ROFA lengths which will exist beyond the end of the ASDA and the LDA when the ASDA and the LDA end at or prior to the end of the runway or the RSA and ROFA lengths which will exist beyond the end of ASDA when the LDA terminates at the runway end and the ASDA extends onto a stopway.

e. Item E. Enter the runway length from runway end to runway end. The area behind a threshold which is used for TORA in at least one direction or for LDA from the opposite direction is runway. The area behind a threshold which is used for ASDA from the opposite direction is either runway or stopway. The area behind a threshold which is used for TODA from the opposite direction is runway and/or clearway. The clearway may be located above a runway or stopway. The runway length is the same for both directions.

f. Items F and G. Enter 0 feet for runway ends without a stopway.

g. Items H and I. Enter 0 feet for runway ends without a clearway.

h. Items N and O. Enter 0 feet for runway ends without displaced threshold.

i. Items P and Q. Enter 0 feet for runway ends without displaced start of takeoff.

j. Items R and S. Enter 0 feet for runways without displaced clearway. Items R and S may not be longer than the clearway length items H and I.

k. Items T and U. Enter a negative (-) distance for runways extending into the departure runway 6protection zone (RPZ).

13. INPUT AIRPLANE DATA AVAILABILITY. Figure A11-2 provides estimated airplane data for which calculated data is not available in appendixes 12 or 13.

Figure A11-1. THIS FIGURE INTENTIONALLY LEFT BLANK

Airplane	Airport Reference Code	OFZ-N		OFZ-CL		C-NG		MU-W	
		feet	(m)	feet	(m)	feet	(m)	feet	(m)
A 300-600	C-IV	19.4	5.91	54.7	16.67	13.3	4.05	23.8	7.25
A 320	C-III	14.5	4.42	39.1	11.92	8.5	2.59	14.5	4.42
ATR-42,-200,-300	B-III	7.8	2.38	27.0	8.23	-1.0	-0.30	1.4	0.43
BAe 146-100	B-III	9.0	2.74	33.2	10.12	-2.5	-0.76	6.2	1.89
Beechcraft 95	B-I	4.7	1.43	10.1	3.08	-5.6	-1.71	1.5	0.46
Beechcraft 1900	B-II	6.2	1.89	18.0	5.49	-7.3	-2.23	0.5	0.15
Beechcraft C99	B-I	5.2	1.58	14.4	4.39	-10.4	-3.17	1.0	0.30
Boeing 707-320	C-IV	13.0	3.96	42.1	12.83	10.0	3.05	31.8	9.69
Boeing 727-200	C-III	12.0	3.66	38.0	11.58	6.9	2.10	21.5	6.55
Boeing 737-200	C-III	11.8	3.60	37.3	11.37	4.8	1.46	13.4	4.08
Boeing 747-400	D-V	25.4	7.74	64.3	19.60	7.7	2.35	57.5	17.53
Boeing 747-SP	C-V	24.9	7.59	65.8	20.10	5.0	1.52	54.0	16.46
Boeing 757-200	C-IV	17.0	5.18	45.1	13.75	12.0	3.66	17.0	5.18
Boeing 767-200	C-IV	18.5	5.64	52.9	16.12	7.5	2.29	28.8	8.78
Boeing 767-300	C-IV	18.5	5.64	52.6	16.03	7.5	2.29	28.8	8.78
C-130 H	C-IV	10.9	3.32	39.4	12.01	3.1	0.94	3.3	1.01
CASA CN-235	B-III	8.3	2.53	26.8	8.17	1.3	0.40	2.1	0.64
Dash 7	A-III	7.5	2.29	31.0	9.45	-2.3	-0.70	1.7	0.52
Dash 8-300	A-III	7.5	2.29	28.9	8.81	-3.4	-1.04	2.1	0.64
DC-8-43	C-IV	13.4	4.08	43.4	13.23	6.0	1.83	26.7	8.14
DC-8-55	C-IV	13.4	4.08	43.4	13.23	6.0	1.83	26.7	8.14
DC-8-63/73	D-IV	13.4	4.08	43.0	13.11	6.0	1.83	26.7	8.14
DC-9-32	C-III	10.7	3.26	31.0	9.45	-2.0	-0.61	11.5	3.51
DC-10-10	C-IV	18.0	5.49	58.4	17.80	20.9	6.37	32.8	10.00
Embraer EMB-110	B-II	6.9	2.10	16.5	5.03	-2.0	-0.61	1.5	0.46
Fokker F-27,-200	B-III	7.6	2.32	28.7	8.75	-4.1	-1.25	2.0	0.61
Fokker F-28,-3000	C-III	11.3	3.44	30.2	9.20	4.4	1.34	9.8	2.99
Gulfstream III	D-II	10.2	3.11	29.2	8.90	-1.5	-0.46	13.2	4.02
JetStar II	C-II	6.6	2.01	20.4	6.22	6.0	1.83	9.5	2.90
L-1011-1,-100,-20	C-IV	20.4	6.22	55.8	17.01	21.9	6.68	36.6	11.16
L-1011-500	D-IV	20.4	6.22	55.8	17.01	21.9	6.68	28.8	8.78
MD-11	D-IV	21.3	6.49	58.8	17.92	20.9	6.37	38.9	11.86
MD-81,-82,-83,-88	C-III	9.8	2.99	34.2	10.42	-1.8	-0.55	13.8	4.21
MD-87	C-III	10.4	3.17	34.8	10.61	-1.8	-0.55	15.0	4.57
SAAB/Fairchild	B-II	9.1	2.77	21.7	6.61	-0.9	-0.27	2.2	0.67
SAAB SF 340 A	B-II	8.8	2.68	23.3	7.10	-1.5	-0.46	2.0	0.61
Shorts 330-200	B-II	6.6	2.01	19.4	5.91	-2.1	-0.64	2.5	0.76
Shorts 360-300	B-II	6.3	1.92	23.8	7.25	-2.0	-0.61	3.0	0.91
Westwind 1124	C-I	7.0	2.13	15.8	4.82	-4.3	-1.31	4.4	1.34

OFZ-N: OFZ height at nose of airplane holding clear of OFZ (airplane perpendicular to runway centerline).
OFZ-CL: OFZ height at centerline of airplane taxiing clear of OFZ (airplane parallel to runway centerline).
C-NG: Center of airplane cockpit to nosewheel.
MU-W: Longitudinal distance from main undercarriage to wingtip.

Figure A11-2. Estimated airplane data elements for input in the computer program

```
N       RUNWAY AND TAXIWAY WIDTH AND CLEARANCE STANDARD DIMENSIONS

                 AIRPORT DESIGN AIRPLANE AND AIRPORT DATA

A  Aircraft Approach Category C
B  Airplane Design Group III
C  Airplane wingspan . . . . . . . . . . . . . . . . . . . . . . . 107.85 feet
D  Primary runway end is precision instrument  1/2 statute mile or less
E  Other runway end is visual

G  Airplane maximum certificated takeoff weight is over 150,000 lbs
H  Airplane wheelbase is less than 60 feet
I  Airplane undercarriage width (1.15 x main gear track) . . . .  19.17 feet
J  Airport elevation . . . . . . . . . . . . . . . . . . . . . .      0 feet
K  Airplane tail height . . . . . . . . . . . . . . . . . . . . .  30.00 feet

F2 Calculate airport design standard dimensions for the above airport
```

Figure A11-3. Example of the airport design airplane and airport data window

```
                 AIRPORT DESIGN AIRPLANE AND AIRPORT DATA

  Aircraft Approach Category C
  Airplane Design Group III
  Airplane wingspan . . . . . . . . . . . . . . . . . . . . .  107.85 feet
  Primary runway end is precision instrument  1/2-statute mile or less
  Other runway end is visual
  Airplane maximum certificated takeoff weight is over 150,000 lbs
  Airplane wheelbase is less than 60 feet
  Airplane undercarriage width (1.15 x main gear track) . . .   19.17 feet
  Airport elevation . . . . . . . . . . . . . . . . . . . . .       0 feet
  Airplane tail height . . . . . . . . . . . . . . . . . . . .  30.00 feet

          RUNWAY AND TAXIWAY WIDTH AND CLEARANCE STANDARD DIMENSIONS

                                                        Airplane  Group/ARC
Runway centerline to parallel runway centerline simultaneous operations
   when wake turbulence is not treated as a factor:

   VFR operations . . . . . . . . . . . . . . . . . . . . . .    700 feet
   VFR operations with intervening taxiway . . . . . . . . . .    800 feet
   VFR operations with two intervening taxiways . . . . . . . .   952 feet
   IFR approach and departure with approach to near threshold  2500 feet less
      100 ft for each 500 ft of threshold stagger to a minimum of 1000 ft.

Runway centerline to parallel runway centerline simultaneous operations
   when wake turbulence is a factor:

   VFR operations . . . . . . . . . . . . . . . . . . . . . .   2500 feet
   IFR departures . . . . . . . . . . . . . . . . . . . . . .   2500 feet
   IFR approach and departure with approach to near threshold . .  2500 feet
   IFR approach and departure with approach to far threshold   2500 feet plus
      100 feet for each 500 feet of threshold stagger.
   IFR approaches . . . . . . . . . . . . . . . . . . . . . .   3400 feet

Runway centerline to parallel taxiway/taxilane centerline . 303.9    400 feet
Runway centerline to edge of aircraft parking . . . . . . . 400.0    500 feet
```

Figure A11-4. Example printout of width and clearance standard dimensions page 1

Taxiway centerline to parallel taxiway/taxilane centerline	139.4	152 feet
Taxiway centerline to fixed or movable object	85.5	93 feet
Taxilane centerline to parallel taxilane centerline	128.6	140 feet
Taxilane centerline to fixed or movable object	74.7	81 feet

Runway protection zone at the primary runway end:

Length	2500 feet
Width 200 feet from runway end	1000 feet
Width 2700 feet from runway end	1750 feet

Runway protection zone at other runway end:

Length	1000 feet
Width 200 feet from runway end	1000 feet
Width 1200 feet from runway end	1100 feet

Departure runway protection zone:

Length	1700 feet
Width 200 feet from the far end of TORA	500 feet
Width 1900 feet from the far end of TORA	1010 feet

Runway obstacle free zone (OFZ) width	400.0	400 feet
Runway obstacle free zone length beyond each runway end		200 feet
Approach obstacle free zone width	400.0	400 feet
Approach obstacle free zone length beyond approach light system .		200 feet
Approach obstacle free zone slope from 200 feet beyond threshold		50:1
Inner-transitional surface obstacle free zone slope		3:1

Runway width	150 feet
Runway shoulder width	25 feet
Runway blast pad width	200 feet
Runway blast pad length	200 feet
Runway safety area width	500 feet
Runway safety area length beyond each runway end or stopway end, whichever is greater	1000 feet
Runway object free area width	800 feet
Runway object free area length beyond each runway end or stopway end, whichever is greater	1000 feet
Clearway width	500 feet
Stopway width	150 feet

Taxiway width	39.2	50 feet
Taxiway edge safety margin		10 feet
Taxiway shoulder width		20 feet
Taxiway safety area width	107.8	118 feet
Taxiway object free area width	171.0	186 feet
Taxilane object free area width	149.4	162 feet
Taxiway wingtip clearance	31.6	34 feet
Taxilane wingtip clearance	20.8	22 feet

Threshold surface at primary runway end:

Distance out from threshold to start of surface	200 feet
Width of surface at start of trapezoidal section	1000 feet
Width of surface at end of trapezoidal section	4000 feet
Length of trapezoidal section	10000 feet
Length of rectangular section	0 feet
Slope of surface	34:1

Threshold surface at other runway end:

Distance out from threshold to start of surface	0 feet
Width of surface at start of trapezoidal section	400 feet
Width of surface at end of trapezoidal section	1000 feet
Length of trapezoidal section	1500 feet
Length of rectangular section	8500 feet
Slope of surface	20:1

REFERENCE: AC 150/5300-13, AIRPORT DESIGN.

Figure A11-5. Example printout of width and clearance standard dimensions page 2

WIND OBSERVATIONS

STATION: ANYWHERE, USA
RUNWAY ORIENTATION: 105.00 195.00 DEGREE
CROSSWIND COMPONENT: 10.50 10.50 KNOTS
TAILWIND COMPONENT: 60.00 60.00 KNOTS
WIND COVERAGE: 98.84 %

	HOURLY OBSERVATIONS OF WIND SPEED (KNOTS)									
DIRECTION	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41 OVER	TOTAL
1	469	842	568	212	0	0	0	0	0	2091
2	568	1263	820	169	0	0	0	0	0	2820
3	294	775	519	73	9	0	0	0	0	1670
4	317	872	509	62	11	0	0	0	0	1771
5	268	861	437	106	0	0	0	0	0	1672
6	357	534	151	42	8	0	0	0	0	1092
7	369	403	273	84	36	10	0	0	0	1175
8	158	261	138	69	73	52	41	22	0	814
9	167	352	176	128	68	59	21	0	0	971
10	119	303	127	180	98	41	9	0	0	877
11	323	586	268	312	111	23	28	0	0	1651
12	618	1397	624	779	271	69	21	0	0	3779
13	472	1375	674	531	452	67	0	0	0	3571
14	647	1377	574	281	129	0	0	0	0	3008
15	338	1093	348	135	27	0	0	0	0	1941
16	560	1399	523	121	19	0	0	0	0	2622
17	587	883	469	128	12	0	0	0	0	2079
18	1046	1984	1068	297	83	18	0	0	0	4496
19	499	793	586	241	92	0	0	0	0	2211
20	371	946	615	243	64	0	0	0	0	2239
21	340	732	528	323	147	8	0	0	0	2078
22	479	768	603	231	115	38	19	0	0	2253
23	187	1008	915	413	192	0	0	0	0	2715
24	458	943	800	453	96	11	18	0	0	2779
25	351	899	752	297	102	21	9	0	0	2431
26	368	731	379	208	53	0	0	0	0	1739
27	411	748	469	232	118	19	0	0	0	1997
28	191	554	276	287	118	0	0	0	0	1426
29	271	642	548	479	143	17	0	0	0	2100
30	379	873	526	543	208	34	0	0	0	2563
31	299	643	597	618	222	19	0	0	0	2398
32	397	852	521	559	158	23	0	0	0	2510
33	236	721	324	238	48	0	0	0	0	1567
34	280	916	845	307	24	0	0	0	0	2372
35	252	931	918	487	23	0	0	0	0	2611
36	501	1568	1381	569	27	0	0	0	0	4046
0	7729	0	0	0	0	0	0	0	0	7729
TOTAL:	21676	31828	19849	10437	3357	529	166	22	0	87864

Figure A11-6. Example printout of wind analysis (two bi-directional runways)

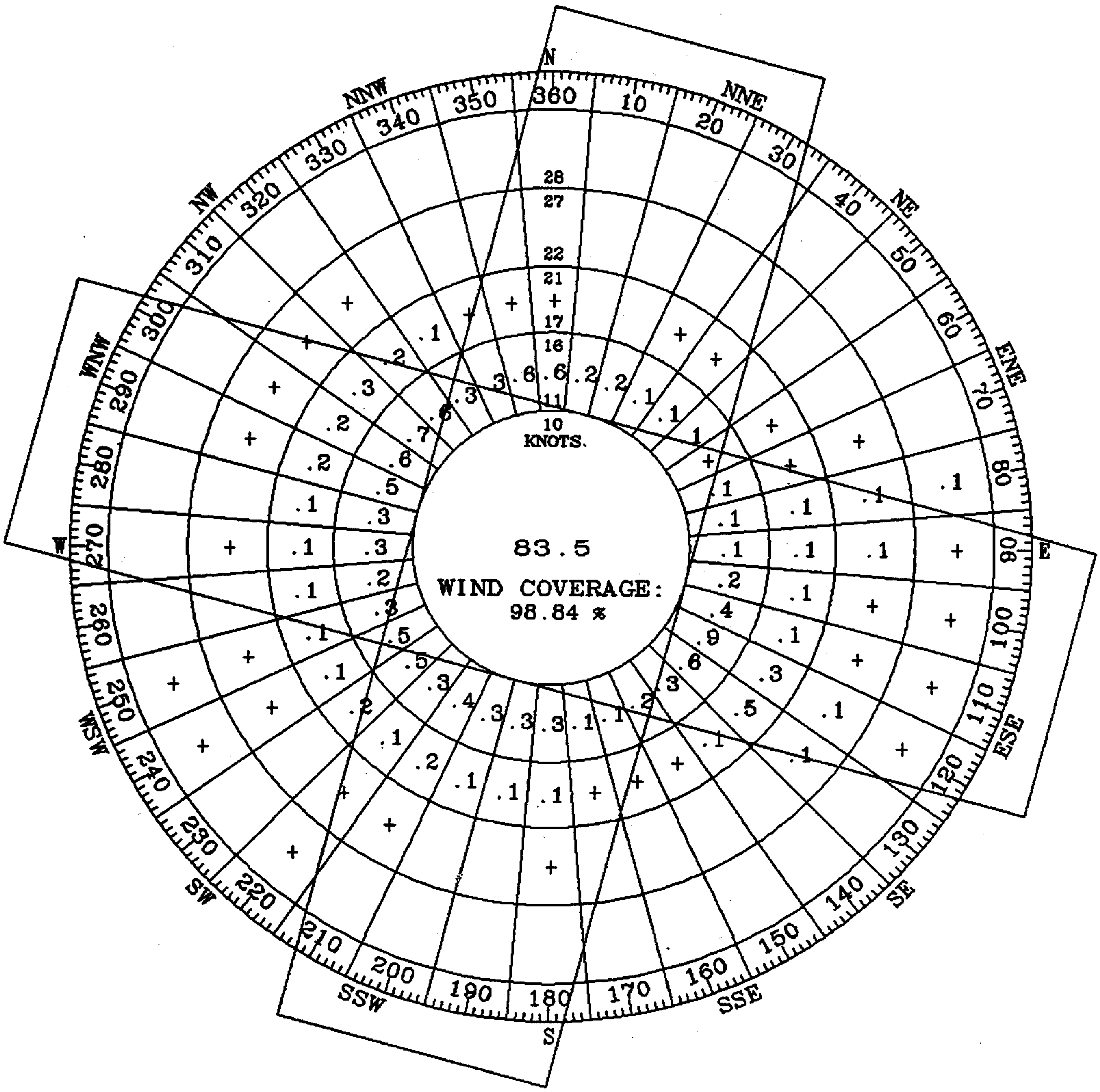


Figure A11-7. Example printout of windrose (two bi-directional runways)

WIND OBSERVATIONS

STATION: ANYWHERE, USA
RUNWAY ORIENTATION: 105.00 DEGREE
CROSSWIND COMPONENT: 13.00 KNOTS
TAILWIND COMPONENT: 5.00 KNOTS
WIND COVERAGE: 80.41 %

	HOURLY OBSERVATIONS OF WIND SPEED (KNOTS)								41	
DIRECTION	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	OVER	TOTAL
1	469	842	568	212	0	0	0	0	0	2091
2	568	1263	820	169	0	0	0	0	0	2820
3	294	775	519	73	9	0	0	0	0	1670
4	317	872	509	62	11	0	0	0	0	1771
5	268	861	437	106	0	0	0	0	0	1672
6	357	534	151	42	8	0	0	0	0	1092
7	369	403	273	84	36	10	0	0	0	1175
8	158	261	138	69	73	52	41	22	0	814
9	167	352	176	128	68	59	21	0	0	971
10	119	303	127	180	98	41	9	0	0	877
11	323	586	268	312	111	23	28	0	0	1651
12	618	1397	624	779	271	69	21	0	0	3779
13	472	1375	674	531	452	67	0	0	0	3571
14	647	1377	574	281	129	0	0	0	0	3008
15	338	1093	348	135	27	0	0	0	0	1941
16	560	1399	523	121	19	0	0	0	0	2622
17	587	883	469	128	12	0	0	0	0	2079
18	1046	1984	1068	297	83	18	0	0	0	4496
19	499	793	586	241	92	0	0	0	0	2211
20	371	946	615	243	64	0	0	0	0	2239
21	340	732	528	323	147	8	0	0	0	2078
22	479	768	603	231	115	38	19	0	0	2253
23	187	1008	915	413	192	0	0	0	0	2715
24	458	943	800	453	96	11	18	0	0	2779
25	351	899	752	297	102	21	9	0	0	2431
26	368	731	379	208	53	0	0	0	0	1739
27	411	748	469	232	118	19	0	0	0	1997
28	191	554	276	287	118	0	0	0	0	1426
29	271	642	548	479	143	17	0	0	0	2100
30	379	873	526	543	208	34	0	0	0	2563
31	299	643	597	618	222	19	0	0	0	2398
32	397	852	521	559	158	23	0	0	0	2510
33	236	721	324	238	48	0	0	0	0	1567
34	280	916	845	307	24	0	0	0	0	2372
35	252	931	918	487	23	0	0	0	0	2611
36	501	1568	1381	569	27	0	0	0	0	4046
0	7729	0	0	0	0	0	0	0	0	7729
TOTAL:	21676	31828	19849	10437	3357	529	166	22	0	87864

Figure A11-8. Example printout of wind analysis (one uni-directional runway)

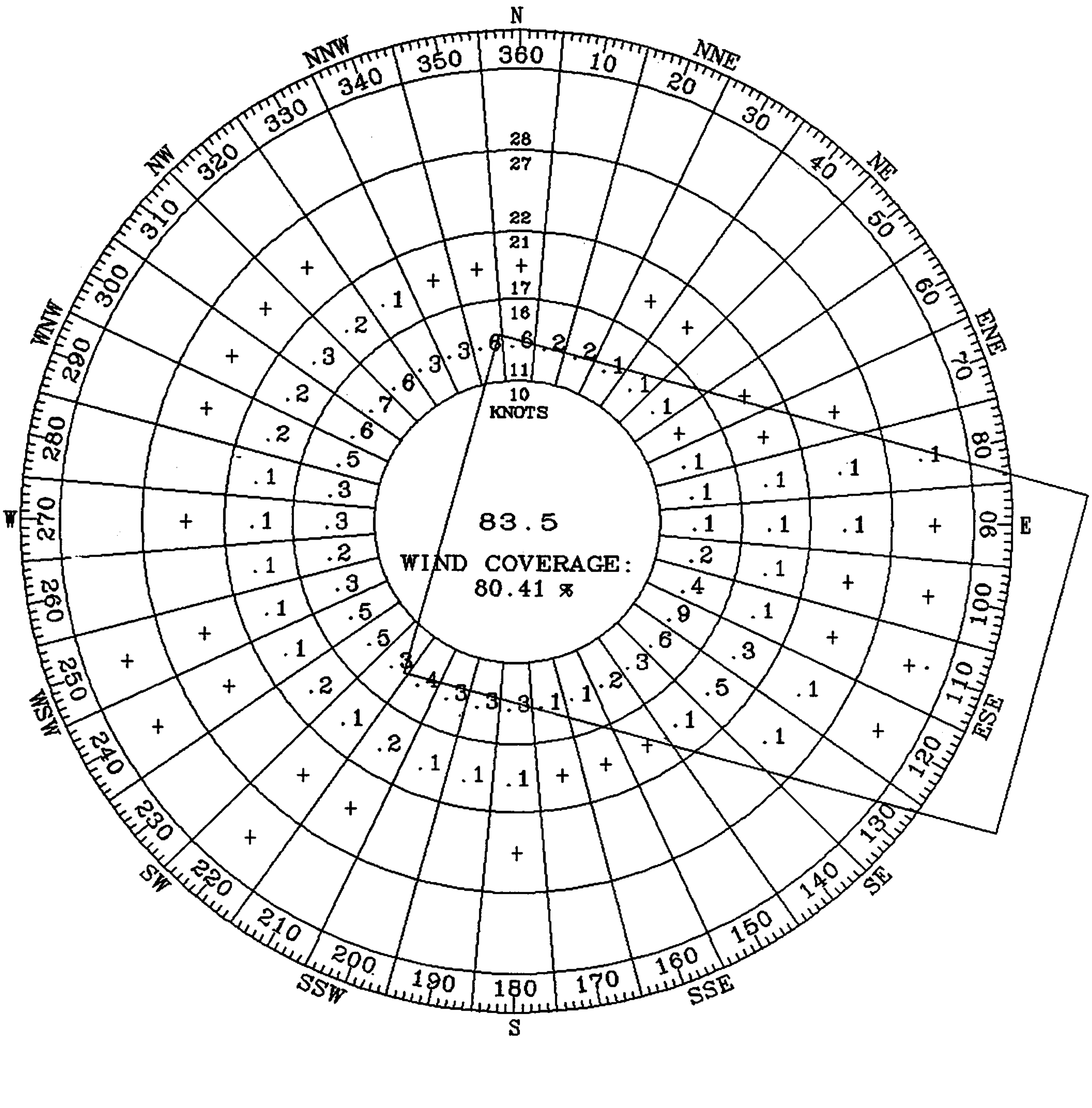


Figure A11-9. Example printout of windrose (one uni-directional runway)

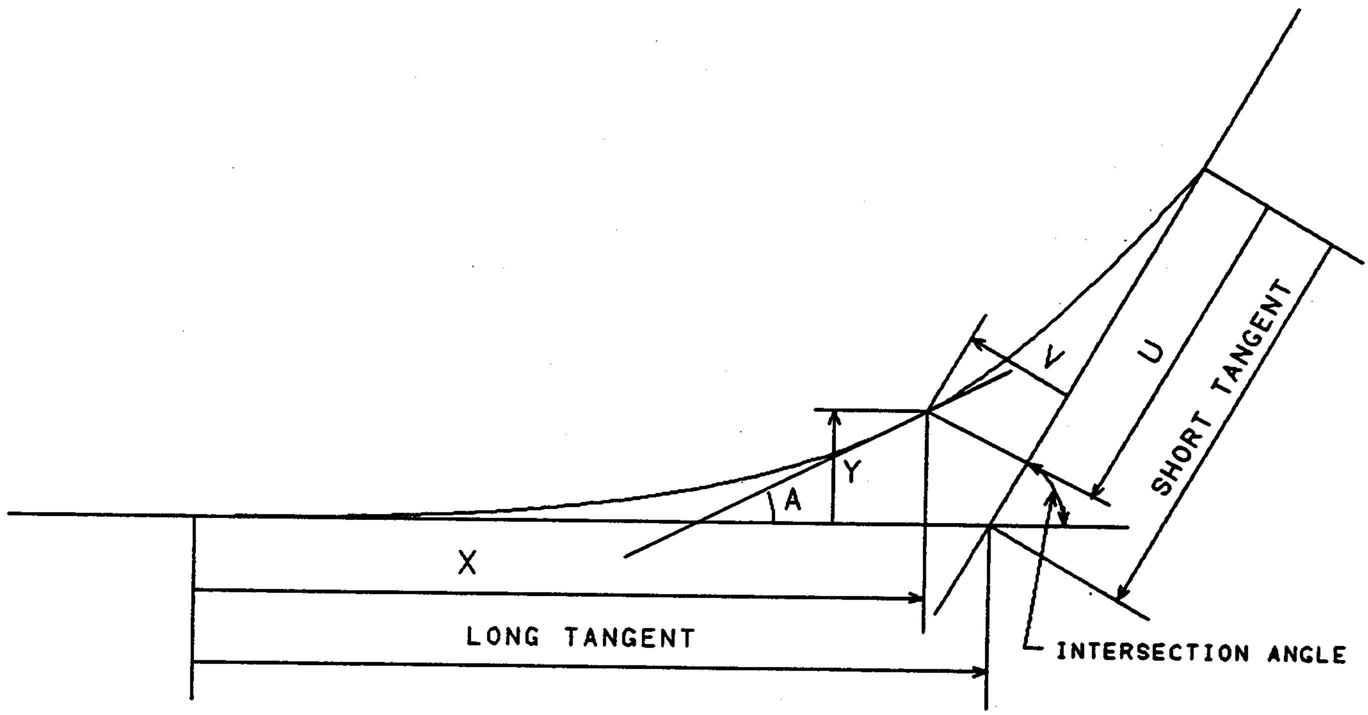


Figure A11-10. Nomenclature used in the taxiway design task

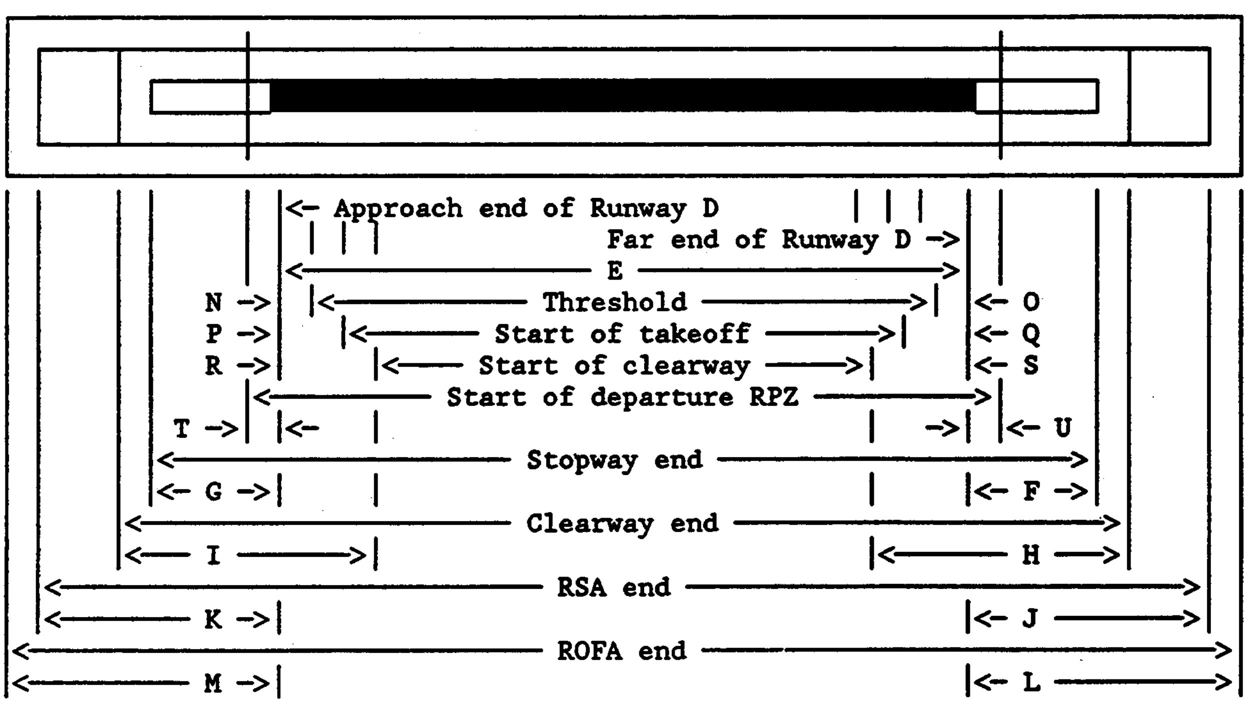


Figure A11-11. Nomenclature used in the declared distance task